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Science 4

Light and Shadows

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Science 4

Light and Shadows

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Science 4
Module 3: Light and Shadows
Student Module Booklet
Learning Technologies Branch
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Teachers	✓
Administrators	
Home Instructors	✓
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Other	

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- Alberta Education, **http://www.education.gov.ab.ca**
- Learning Technologies Branch, **http://www.education.gov.ab.ca/ltb**
- Learning Resources Centre, **http://www.lrc.education.gov.ab.ca**

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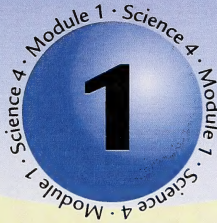
to Module 3 of Science 4



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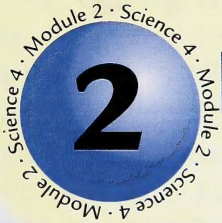

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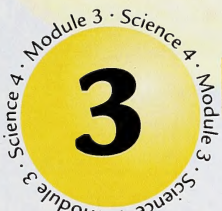
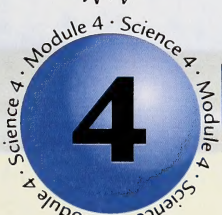


Module 3
Light and Shadows



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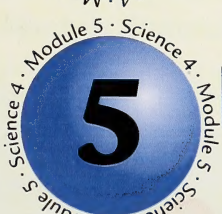

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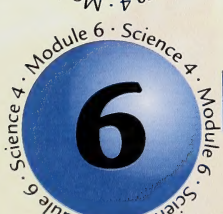


Module 6
Relationships

There are six modules in this course. It is recommended that you work through the modules in order because the concepts and skills introduced in one module will be reinforced, extended, and applied in later modules.

Module 1 contains general information about the course components, additional resources, icons, assessment, and strategies for completing your work. If you do not have access to Module 1, contact your teacher to obtain this important information.

Contents

Module Overview 6

Section 1: Light 8

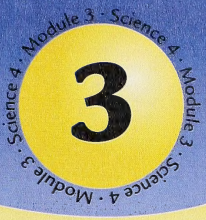
Lesson 1: Lighting or Lit Up? 9
Activity 1: Crackling Mints 14
Lesson 2: Artifical Light Sources 18
Activity 2: Light Bulbs 23
Lesson 3: Out and Away 29
Activity 3: Circle of Light 31
Lesson 4: Straightening It Out 38
Activity 4: Light Spots 39

Section 1 Conclusion 45
Optional Follow-up Activities 46

Section 2: Exploring Shadows 52

Lesson 5: Sun Shadows 53
Activity 5A: Making Predictions by Using a Flashlight 54
Activity 5B: Measuring Sun Shadows 57
Lesson 6: Shadow Shape 64
Activity 6: Exploring Shadows 66
Lesson 7: Moving the Source 74
Activity 7: Shadow Play 75
Lesson 8: Transparent, Translucent, and Opaque 81
Activity 8: How Much Light? 85

Section 2 Conclusion 91
Optional Follow-up Activities 92



Light and Shadows

Section 3: Twisting, Bouncing, and Breaking Up 98

Lesson 9: Changing Directions 99
Activity 9A: Reflection 99
Activity 9B: Refraction 101
Lesson 10: Objects That Reflect 106
Activity 10: Reflectors 109
Lesson 11: Reflecting Technologies 115
Activity 11: Making a Kaleidoscope 117
Lesson 12: Bending Light 126
Activity 12: Changing the Direction of Light 127
Lesson 13: Lenses 134
Activity 13: Lens Maker 139
Lesson 14: White Light 144
Activity 14: Bubble Rainbows 146
Lesson 15: Making Colours 149
Activity 15: Colour Mixing 150

Section 3 Conclusion 157
Optional Follow-up Activities 158

Module Summary 166

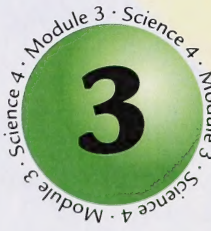
Glossary 167

Module Overview

Light is like the air you breathe. It is all around you, and you need it to survive. If light is this important, shouldn't you be thinking about it all the time? You probably don't think about light at all, just as you don't think about breathing to stay alive. In fact, most people rarely think about the light that is around them every day of their lives.

In this module, you will explore light. You will find out what makes light and what affects or changes light.

In the first section of this module, you will find out about light sources or objects that make light. You will discover how light sources have changed since people used torches to light their way at night. In Section 2 you will experiment with shadows. You will also see what kind of objects create shadows. In Section 3, you will explore changing the direction of light. You will see that light can be reflected and bent. You will also discover that when light is bent it can be split into different colours.



Module 3
Light and Shadows

Section 1
Light

Section 2
Exploring Shadows

Section 3
Twisting, Bouncing, and Breaking Up

How Will You Be Marked?

Your mark on this module will depend on how well you complete the two Assignment Booklets.

This is how the marks are distributed:

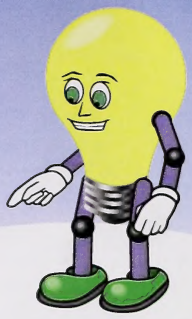
Assignment Booklet 3A	
Section 1 Assignment	61 marks
Section 2 Assignment	36 marks
Total	97 marks
Assignment Booklet 3B	
Section 3 Assignment	82 marks
Total	82 marks

Be sure to check with your teacher to see if this mark distribution is appropriate for you. Some teachers like to include other reviews and assignments. When you get the assignments back from your teacher, be sure to read the comments and talk about them with your home instructor.

When you do the assignments, work slowly and carefully under the instruction of your home instructor or teacher. You may use your course materials to help you, but you must do the assignments by yourself.

Section 1

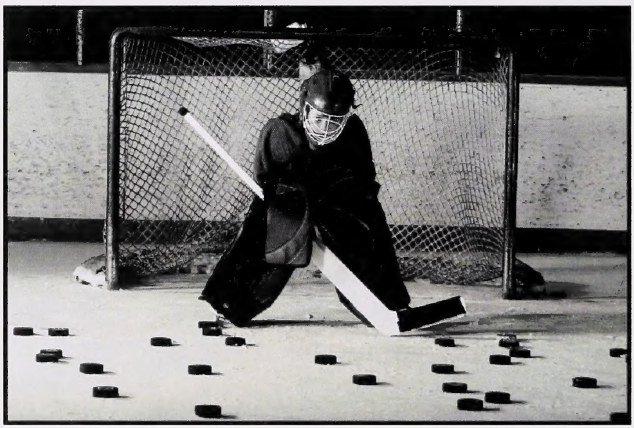
Light



Introduction

Some things in the world make their own light. Most objects, including YOU, can't make their own light. Most things can only be seen when they are lit up by a light source. The main light source on Earth is the Sun. People have developed other light sources as well.

Imagine trying to fit your entire day of work and play into the hours of sunlight. In Canada, this wouldn't be too hard to do in the summer. In the winter, you might not have enough time. How would you fit all the things you want or need to do into 6 or 7 hours? What would you cut out? Finishing your homework? Playing with friends? Doing chores around your home?



Long ago, people discovered fire. Fire was used to light and heat caves. People could finally see at night. Fire was useful, but it was also dangerous. People have been trying to create safe light sources for hundreds of years. You can see examples of these light sources in your home.

In this section, you will explore artificial light sources. You will find out how they have changed over time. You will see how the lights and lamps you use have been developed.

Lesson 1: Lighting or Lit Up?

Have you ever thought about how you are able to see things? Did you wonder why you can't see in the dark? You know that you can see when you turn on a light. With the light on you can see the shapes and colours of everything around you. Why is this? In this lesson you will find out.

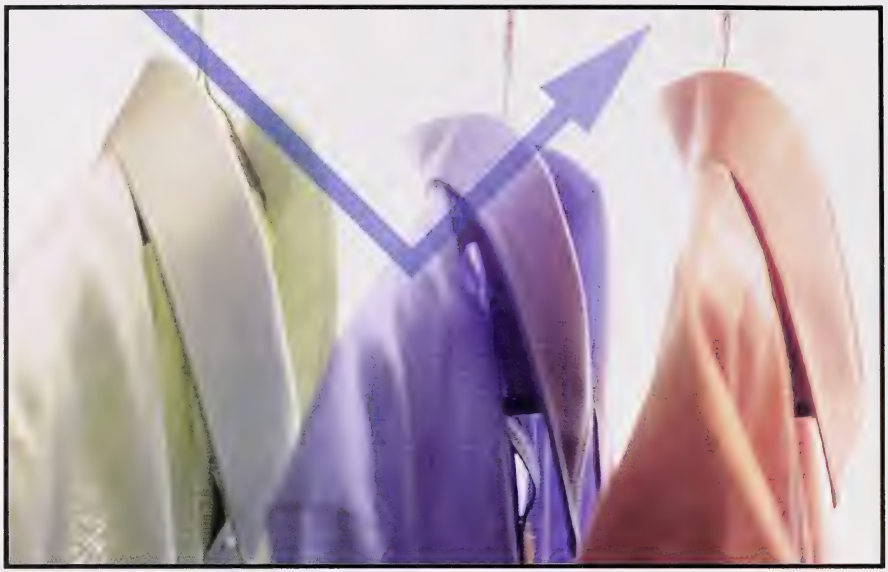
luminous: having its own light

reflect: to turn back, bounce back, or throw back light, heat, or sound

You can see only when enough light reaches your eyes. Your eyes and your brain make sense of the light, and you see. Light comes to your eyes in two different ways:

- An object can be **luminous** and make its own light.
- An object can **reflect** light.

What has to happen for you to see a blue shirt in the closet?

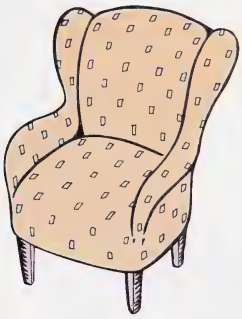


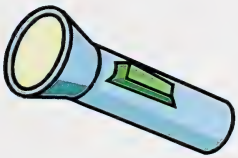
light source: an object that makes its own light

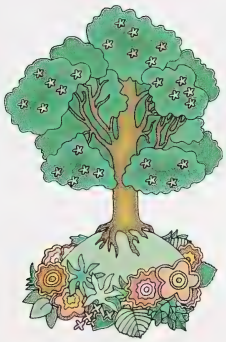
Light has to go from the shirt to your eye. In a dark closet you can't see where your blue shirt is. You can only see it when a **light source** is available. Then, light from the light source can bounce from the shirt to your eyes. Where there is no light, you can't see.

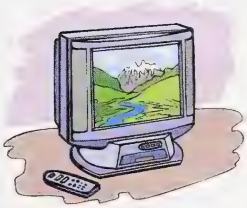
More things in the world reflect light than make light. Can you think of things that make their own light? You might think of stars, fireflies, fires, or light bulbs.

Look at the following pictures.









1. Which objects make light?

_____

_____

_____

2. Which objects only reflect light?

_____

_____

_____

Check your answers for these questions in the Suggested Answers at the end of this lesson.

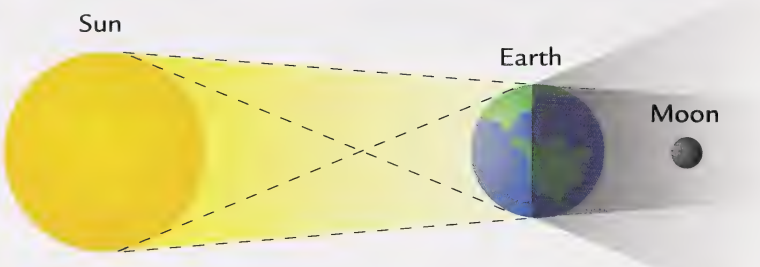
The Night Sky

On a clear night, you can see thousands of stars and the Moon in the sky. Stars make their own light, and you can see them from billions of kilometres away. The Moon does not make its own light. It reflects light from the Sun.

shadow: a dark shape caused by something or someone blocking light

lunar: having to do with the Moon

Sometimes, the Moon travels through Earth's **shadow**. This is called a **lunar** eclipse. A lunar eclipse only happens when there is a full moon. It's the only time Earth is between the Sun and the Moon.



Note: The difference in sizes of the Sun, Earth, and the Moon are much greater than the diagram shows.

Earth's shadow has lighter and darker parts to it. If the Moon is in the lighter part of the shadow, you may have a hard time seeing the shadow. When the Moon travels through the darkest part of the shadow, it is a total lunar eclipse. All or part of the Moon gets much darker.

During a total lunar eclipse, the Moon may take on beautiful colours. The colours appear because Earth's atmosphere filters light from the Sun. The amount of dust, clouds, and ash in the atmosphere changes the light's colour. You might see different colours ranging from red to orange and purple.

You can see some pictures of a lunar eclipse at these websites:

- National Geographic

  http://news.nationalgeographic.com/news/2003/05/0512_030512_lunareclipse.html

- SPACE.com

  http://www.space.com/spacewatch/lunar_eclipse_030515.html

- Lunar Eclipse Photo Gallery

  http://www.mreclipse.com/LEphoto/LEgallery1/LEgallery1.html

- Science, Optics, and You

  http://micro.magnet.fsu.edu/optics/tutorials/index.html

  At this website, you can view a model of a lunar eclipse and even control the Moon's path through Earth's shadow. Scroll to "Eclipse of the Moon."

- NASA

  http://sunearth.gsfc.nasa.gov/eclipse/eclipse.html

  It's easy to find when the next lunar eclipse will happen. This website lists dates of eclipses.

Have you ever owned glow-in-the-dark clothing, toys, or keychains? Some substances give off a soft light when they are in the dark. These substances are luminous. They make their own light.

Activity 1: Crackling Mints

You need a very dark room, such as the bathroom or a closet, with the lights off to do this activity. You also need a mirror so you can see the flashes of light!

What you need

- a very dark room
- 2 Wint-O-Green Lifesaver™ candies
- a mirror

What to do

Read steps 1 to 4 before you begin this activity.

1. Go into a very dark room or closet and turn out the lights. Take the mirror and candies with you.

2. Wait for your eyes to adjust to the darkness (about 5 minutes).

3. Put the two candies into your mouth.

4. Look into the mirror. Open your mouth as you chew the candies.

5. What did you see?

_____

_____

6. Did the Wint-O-Green candies give off their own light or did they reflect light from a light source?

_____

_____

The website How Stuff Works explains what happens in this experiment.

http://science.howstuffworks.com/question505.htm

You and your home instructor should visit this site together to see the explanation.

Check your answers for this activity in the Suggested Answers at the end of this lesson.

Some things on Earth make light. This light can then reflect off other objects and you can see them. When a light source is taken away or turned off, you can no longer see the source or the objects around it. In the next section, you will find out more about the most important light source for Earth—the Sun. Now, share what you have discovered about light by completing your assignment question.

Turn to Assignment Booklet 3A and complete question 1 of the Section 1 Assignment.

Suggested Answers

Lesson 1: Lighting or Lit Up?

1. Which objects make light?

The television, the flashlight, and the fire make light.

2. Which objects only reflect light?

The tree, the chair, and the people only reflect light.

Activity 1: Crackling Mints

5. What did you see?

Were you surprised? There should be blue-white sparks in your mouth.

6. Did the Wint-O-Green candies give off their own light or did they reflect light from a light source?

The Wint-O-Green candies give off their own light. There was no other source for the light.

Key Words

light source: an object that makes its own light

luminous: having its own light

lunar: having to do with the Moon

reflect: to turn back, bounce back, or throw back light, heat, or sound

shadow: a dark shape caused by something or someone blocking light

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Lesson 2: Artificial Light Sources

Look around your home. How is it lit at night? Do you have torches stuck in holders on the walls? Do you have an oil-burning lamp beside your bed? Most people don't. Most homes have lights that are run by **electricity**.

electricity: a form of energy that can produce light, heat, and motion

Have you ever had the electricity go out in your home? Did you light candles in order to see things? Before people used electricity, flames were used as a light source inside and outside homes. In today's lesson, you will explore different ways that people have created light.

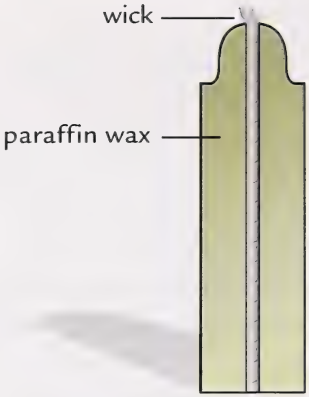
People have used fire for thousands of years. The first fire may have been started when lightning struck a tree or bush. At first, people had to keep their fires burning at all times. They hadn't learned how to start a new fire.

Thousands of years ago, people would have used something as simple as a burning stick (a torch) to light the way. A burning stick didn't last long, and the flame was easily blown out. People discovered ways to make better torches. They found they could make a bigger flame with many sticks tied together. They could also keep the flame burning longer with a torch dipped in fat or tar.

Torches helped people see after the Sun had set, but open flames are dangerous. Think about what could happen inside a cave or a building.

People developed other ways to create light. A simple bowl of animal fat with a small fibre wick became an oil lamp.

Lamps became more complex over time. A lamp 2500 years ago was often made of pottery and only the wick was outside.



The development of candles took a bit longer. Originally candles were made of animal fat. It's only in the last 200 years that you could find a less smelly candle. The discovery of paraffin wax (a wax made from oil) was the key. Most modern candles have a cotton wick covered by wax.

The combination of a wick and wax provides a light source that burns for a long time.

During the 1800s, oil and gas lanterns were common sources of light. Oil and gas lanterns still used flames to give off light. Lanterns were better than candles for these reasons:

- They burned for a longer time.
- They did not blow out as easily.
- They could be refilled with fuel.

In the late 1800s came the invention of easy-to-use "flameless" lights. They were powered by electricity. What was needed to make them popular? They needed a good source of electric power. You can thank inventor George Westinghouse for how easy it is to turn on electric lights. His inventions and companies helped shape the way electricity was moved and sold.

incandescent: a light source (for example, a light bulb) that uses a vacuum and filament

vacuum: a space containing no air, or from which the air has been removed

filament: the wire (in a light bulb) that glows when electricity passes through it

A very common light source in our homes is the **incandescent** light bulb. An incandescent light bulb uses electricity to create light. Light bulbs were safer and created less pollution than the lamps and candles used in the past.

You can find out about the history of the incandescent light bulb at

http://inventors.about.com/library/inventors/blight2.htm

In 1878, Sir Joseph Wilson Swan, an English physicist, invented a practical electric light bulb. The bulb lasted about 13 hours.

Incandescent lights are very common. They have been improved so much that they can last for hundreds—even thousands—of hours. You can buy bulbs that have different levels of brightness. The more power bulbs use, the brighter they usually are. The power rating of a bulb is given in watts (W). As you would expect, a 100 W bulb is brighter than a 60 W bulb.

SAFETY HINT: Lamps are designed to use certain light bulbs. They can be used safely if the bulbs used are not too powerful. It is important that you check this maximum level before changing a light bulb.

Although incandescent light bulbs are very common, they have some disadvantages:

- They give off large amounts of heat.
- They burn out quite quickly.
- They use lots of electricity.

Inventors have worked on these three problems. They have created a different light source, called a fluorescent tube, which is a long tube with a special gas inside it. The electricity flows from one end of the tube to the other and lights up the gas inside. A more compact design can be used in ordinary lamps.

fluorescent: a light source made of a long tube with a special gas inside that lights up when electricity flows from one end of the tube to the other

Fluorescent Tube

Compact Fluorescent Bulb

Activity 2: Light Bulbs

One of the disadvantages of an incandescent light bulb is that it gives off heat. How much heat does it give off? Does a fluorescent light bulb give off heat as well? In this activity, you will find out!

What you need

- a fluorescent light
- an incandescent light
- a thermometer*
- a watch

* preferably an outdoor alcohol-type (red-fluid) thermometer

What to do

Ask your home instructor to help you with this activity.

These steps refer to both incandescent and fluorescent lights. Do you have access to both types of lights? If you don't, follow the steps with just one type of light. You can check the Suggested Answers to see how the other type of light might have worked.

If you are using lights in the ceiling, ask an adult to help you take this temperature measurement.

1. Make sure the lights you are testing have been off for an hour.

2. Measure the temperature 1 cm from each light. Take your measurement near the middle of the light. You may need an adult helper to get the thermometer in place. Keep the thermometer near the light for about 1 minute.

   a. Temperature near the incandescent light: _____

   b. Temperature near the fluorescent light: _____

3. Turn on both lights. Leave them on for 30 minutes.

These bulbs may be hot—do not touch them!

4. Again, measure the temperature 1 cm from each light.

   Try to take the measurement in the same place as your first measurement. You may need an adult helper to get the thermometer in place.

5. Again, keep the thermometer near the light for about 1 minute.

   a. Temperature near the incandescent light: _____

   b. Temperature near the fluorescent light: _____

6. What was the change in temperature around each bulb?

   a. Incandescent bulb: _____ – _____ = _____

   b. Fluorescent bulb: _____ – _____ = _____

7. Which type of bulb turns more energy into heat?

_____

8. Which type of light could you use to heat a small room?

_____

Check your answers for this activity in the Suggested Answers at the end of this lesson.

New, small fluorescent bulbs have been invented that can be used in lamps and light fixtures where we would have normally used an incandescent bulb.

Mini-fluorescent bulbs don't burn out as often as incandescent bulbs. They last about 8000 hours. These bulbs cost more to buy, but people can save between $30 and $45 on electricity in the bulb's lifetime. The next time your family needs to buy light bulbs, tell them why they should buy the new, small fluorescent bulbs.

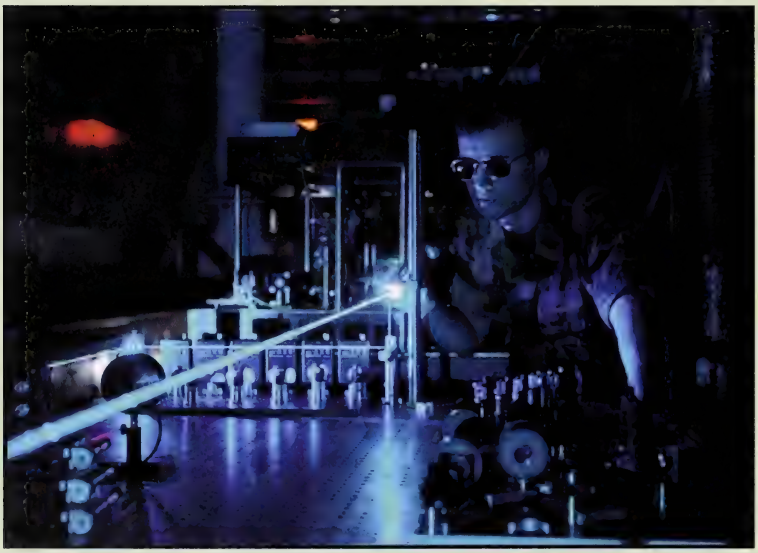
Scientists are working on better light sources all the time. Take "A Closer Look" at a laser, which is another important light source.

Laser

The word *laser* stands for Light Amplification by Stimulated Emission of Radiation. Thank goodness scientists came up with a shortened form!

A laser is a device that makes an intense beam of light. This beam of light can be used in many different ways:

- to cut metals
- to perform surgery
- in laser printers
- in compact disc players
- in bar-code scanners in grocery stores



Turn to Assignment Booklet 3A and complete question 2 of the Section 1 Assignment.

Suggested Answers

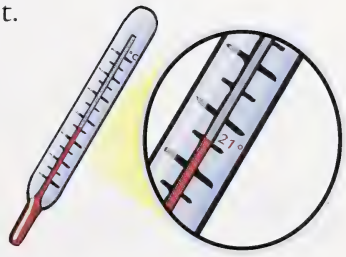
Activity 2: Light Bulbs

2. Answers will vary. Sample answers follow.

a. Temperature near the incandescent light: **21°C**

b. Temperature near the fluorescent light: **21°C**

5. Answers will vary. Sample answers follow. You will likely see a change in temperature near the incandescent light. There will likely be little change near the fluorescent light.



a. Temperature near the incandescent bulb: **24°C**

b. Temperature near the fluorescent bulb: **21°C**

6. Answers will vary. Sample answers follow. You will likely see a change in temperature near the incandescent light. There will likely be little change near the fluorescent light.

a. Incandescent bulb: **24°C – 21°C = 3°C**

b. Fluorescent bulb: **21°C – 21°C = 0°C**

7. Which type of bulb turns more energy into heat?

The incandescent bulb turns more energy into heat.

8. Which type of light could you use to heat a small room?

You could use an incandescent light. It gives off more heat than a fluorescent light.

Key Words

electricity: a form of energy that can produce light, heat, and motion

filament: the wire (in a light bulb) that glows when electricity passes through it

fluorescent: a light source made of a long tube with a special gas inside that lights up when electricity flows from one end of the tube to the other

incandescent: a light source (for example, a light bulb) that uses a vacuum and filament

vacuum: a space containing no air, or from which the air has been removed

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Lesson 3: Out and Away

Have you noticed that as long as there is nothing between you and a light, you can see it, no matter from which direction you are looking? This is an important characteristic of light that you will find out more about in today's lesson. You will also discover what happens where there is something in the way.

Shadow Plays

Shadow plays are popular in Asia. Shadow plays were first performed in China over 1000 years ago.

At that time, the poor people in China could not afford to put on or go to plays that had actors in them, so they made puppets whose shadows were cast onto a screen. People watched the story acted out by the movement of the shadow characters on the screen.

Shadows can be used to tell you in which direction someone is moving.

If you notice that a person's shadow on a wall is getting smaller, the person is moving toward the wall. If a person's shadow on a wall is getting bigger, the person is moving away from the wall.

In what direction does light travel? What happens when something gets in the way? You will find out in Activity 3: Circle of Light.

Activity 3: Circle of Light

Does light really travel out from a light source in all directions?

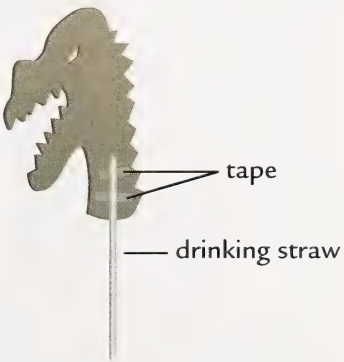
What you need

- a small lamp with no lampshade on it
- a sheet of white paper
- a ruler, metre-stick, or tape measure
- a drinking straw*
- lightweight cardboard
- scissors
- tape
- a helper—the puppeteer
- a room that can be darkened

* An ice-treat stick, thin dowel, wooden spoon, or pencil will also work.

What to do

1. Make a puppet out of the cardboard. An animal or car shape would be good. You will see more detail than with a simple shape like a circle or square. Tape the cardboard shape onto the straw. The puppeteer will hold onto the straw to move the puppet.



2. Place the lamp in an area where you can move all the way around it.

Ask your home instructor to help you tape down the lamp cord or arrange things so that you won't trip on the cord.

3. Switch on the lamp.

4. Turn off the other lights in the room. If it is daytime, you will have to make sure the room is dark. You need to be able to see the shadows.

Be careful when working near a light bulb; it gets very hot.

5. Hold the paper in front of you about 60 cm away from the light. This is your starting position. Have your puppeteer put the puppet about halfway between the light and the paper. What do you see on the paper?

_____

6. Slowly move the paper and the puppet around the light. Keep the paper and the puppet the same distance from the light. Watch the shadow on the paper. Keep moving around the light until you are back to where you started.

7. As you moved around the light, did the shadow ever disappear?

_____

8. How do you know that light travels out from a light source in all directions?

_____

_____

_____

9. Now have the puppeteer move the puppet closer to the paper (to about 15 cm from the paper).

10. Did the shadow on the paper change? If it changed, how did it change?

_____

_____

11. Have the puppeteer move the puppet closer to the light (to about 15 cm from the light).

12. Did the shadow change? If it changed, how did it change?

_____

_____

13. Have the puppeteer move the puppet so the shadow falls on the edge of the paper by your right hand. The shadow will fall on the paper like the one in the diagram.

14. Have the puppeteer move the puppet to your left.

15. Did the shadow on the page move? If it moved, which way did it move?

_____

_____

Keep your shadow puppet. You can use it in Section 2: Activity 7.

Check your answers for this activity in the Suggested Answers at the end of this lesson.

Of course, you can put objects in the way of a light so that it can't travel in a certain direction.

When a lamp is placed in the corner of a room, the walls stop the light from travelling farther behind the lamp and reflect it back into the room.

A desk lamp has a covering over the top of the lamp so that the light travelling upward is blocked and reflected downward onto your paper.

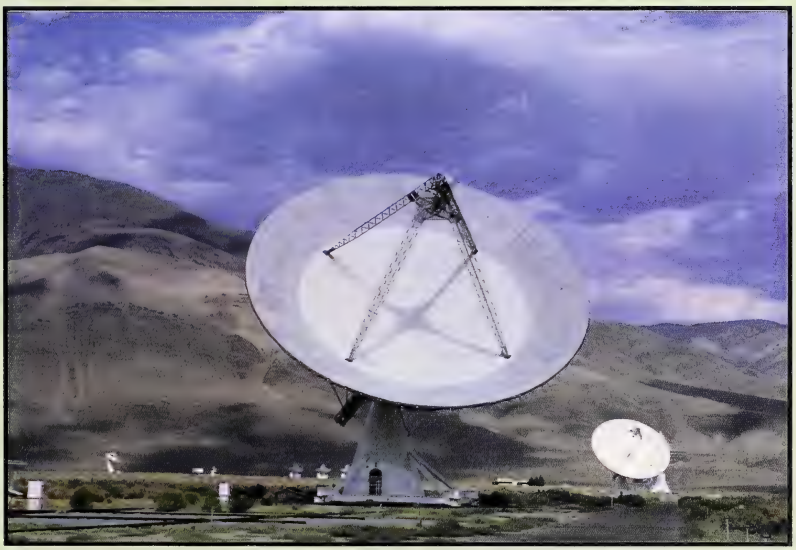
Light from a ceiling fixture doesn't travel far upward. It is stopped by the ceiling of the room. The ceiling reflects the light back into the room and makes it brighter.

Take "A Closer Look" at how light can be directed in a certain way.

Parabolic Headlights and Satellite Dishes

If you look inside a car's headlight, the shape is very special. It has this shape because it gives the most light where it is needed. Mathematicians call this shape a circular paraboloid (you do not have to remember this term).

The back of the headlight stops the light from travelling in that direction. It reflects the light out the front of the headlight. In this way, a very strong light beam is directed out onto the road.



Satellite dishes have a similar shape. The shape is very good for collecting weak signals from space.

Light will travel out from a light source unless there is an object that stops it. The world would be a very different place if this wasn't true!

In the next lesson, you will find out more about the way light travels.

Turn to Assignment Booklet 3A and complete question 3 of the Section 1 Assignment.

Suggested Answers

Activity 3: Circle of Light

5. Hold the paper in front of you about 60 cm away from the light. This is your starting position. Have your puppeteer put the puppet about halfway between the light and the paper. What do you see on the paper?

You should see a shadow of the puppet on the paper.

7. As you moved around the light, did the shadow ever disappear?

No, the shadow should not have disappeared at any time.

8. How do you know that light travels out from a light source in all directions?

You know that light travels out in all directions from a light source because it made a shadow no matter where in the circle (the path around the lamp) the object and paper were placed. If the shadow had disappeared at some point, you would have known that there was no light travelling in that direction. The shadow never disappeared because light was travelling out in all directions.

10. Did the shadow on the paper change? If it changed, how did it change?

Yes, the shadow did change. It became smaller.

12. Did the shadow change? If it changed, how did it change?

Yes, the shadow did change. It became larger.

15. Did the shadow on the page move? If it moved, which way did it move?

Yes, the shadow did move on the page. It moved the same way the puppet was moved.

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Lesson 4: Straightening It Out

You have discovered that light travels out from a source in a straight line unless something gets in its way. What happens then? Will light go around corners? In this lesson, you will find out in which direction light travels.

What can happen when light strikes an object? There are a lot of things that could happen. It could go right on through. It could just stop like a bug on a windshield. It could bounce off like a basketball on the backboard. It could break into pieces like a glass falling on a sidewalk.

In Lesson 1, you discovered that you only see when light gets to your eyes. You only see an object when your eyes get light coming from it. How can it get there? Does light only travel directly from an object? Find out in Activity 4: Light Spots.

Activity 4: Light Spots

In this activity, you will see if light bends around corners.

Ask your home instructor for help with this activity.

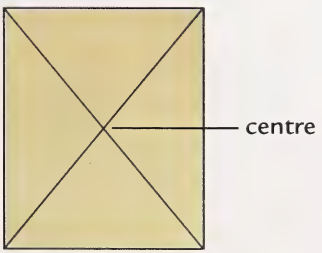
What you need

- 3 pieces of cardboard exactly the same size
- 1 piece of black paper (cardstock)*
- a flashlight
- scissors
- modelling clay
- a knitting needle or skewer
- a ruler
- a pencil
- a room that can be darkened

* The piece of black cardstock should be the same size as the cardboard.

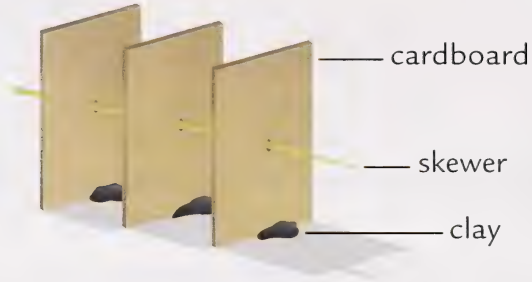
What to do

1. Cut a small hole in the centre of each piece of cardboard. To find the centre, draw lines across each piece, as shown in this diagram:

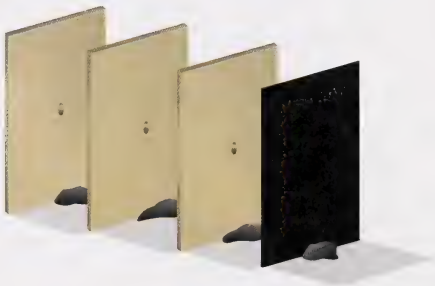


2. Stand up all three pieces of cardboard in a row. Use the modelling clay to keep them standing up.

3. Use the skewer or knitting needle to make sure the holes are all in a straight line. (Then remove the skewer.)



4. Use the modelling clay to stand the piece of black paper after the last piece of cardboard, as shown in the following picture. Remember, the black paper should be the same size as the cardboard pieces.



5. Turn out the lights. Hold a flashlight in front of the first piece of cardboard. Shine the flashlight through the holes in the three pieces of cardboard onto the piece of black paper.

6. Where is the spot of light on the black paper?

_____

7. Move the centre piece of cardboard to one side by 1 cm. The holes are now no longer lined up. Will a spot of light show up on the black paper when you shine the flashlight through the holes? Make your prediction.

_____

8. How do you think the spot of light will show up on the black paper?

_____

9. Shine the flashlight through the holes in the cardboard. Where do you see the spot of light?

_____

10. Does light go around corners? Explain your answer.

_____

_____

_____

Check your answers for this activity in the Suggested Answers at the end of this lesson.

Now that you know light travels in straight lines, here are some things to think about:

- Where is the light source? Can you see it?
- There is a wall or other obstacle between you and the light source. How can you still see the light, if light only travels in a straight line?

absorb: to take in and hold

opaque: not allowing light to travel through

Remember that light can be **absorbed** or reflected by the **opaque** objects around it!

Look at the following photo. Light from the lamp travels in a straight line to the ceiling, to the wall behind the lamp, and to the furniture around it. Which items absorb light? Which items reflect light?

Did you guess that the furniture absorbed light? Did you guess that the walls and ceiling reflect light?

The light that starts at the light source travels in a straight line. It reflects off opaque objects that stand in its path. In this way, light beams from a single light source can fill a room and allow you to see all of the objects, even those that are hidden from the light source.

Light from the Sun acts in the same way as a lamp or flashlight. Clouds are opaque. However, even with cloudy skies, you are able to see things around you.

In the next section, you will discover more about what happens when light is blocked.

Turn to Assignment Booklet 3A and complete question 4 of the Section 1 Assignment.

Suggested Answers

Activity 4: Light Spots

6. Where is the spot of light on the black paper?

The spot of light is in the centre of the black paper.

7. Move the centre piece of cardboard to one side by 1 cm. The holes are now no longer lined up. Will a spot of light show up on the black paper when you shine the flashlight through the holes? Make your prediction.

Answers will vary because this is a prediction. A sample answer follows.

If the holes do not line up, light will not reach the sheet of paper.

8. How do you think the spot of light will show up on the black paper?

Answers will vary. A sample answer follows.

The spot of light will not show up on the paper.

9. Shine the flashlight through the holes in the cardboard. Where do you see the spot of light?

The spot of light shows up on the middle piece of cardboard. No spot of light can be seen on the sheet of black paper.

10. Does light go around corners? Explain your answer.

No, light does not go around corners. I saw that the light was blocked when the holes didn't line up. The light didn't move off a straight line to go through the holes.

Key Words

absorb: to take in and hold

opaque: not allowing light to travel through

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Section 1

Conclusion

It has been a long time since people needed a lightning storm to have night light!

The Sun has always been the main light source during the day, but flames and artificial light sources allow people to play, work, and learn when daylight changes into night.

Scientists are working to create new light sources that produce more light with less electricity.

Optional Follow-up Activities

Activity 1: Bulb Safety Check

Sometimes people change bulbs in lamps without checking the recommended maximum watts. In this activity, you will check the bulbs in the lamps in your home.

What to do

Caution: Adult supervision is required for this activity.

1. Check the recommended maximum watts for the lamps in your home. This information is usually stamped on the lamp or is stated in a sticker on the lamp.

2. If the lamp has been on recently, do not touch the bulb. Wait until the bulb has cooled.

3. Fill in the given chart with your findings. An example is provided for you. The bulb being used in a lamp is safe if it is equal to or less than the recommended watts.

Description of Lamp	Recommended Maximum Watts	Light Bulb Used in the Lamp	Is this bulb safe in this lamp?
living-room lamp	60 watts	100 watts	no

If you found unsafe bulbs in any of your lamps, make sure you tell an adult so that a proper bulb can be used!

Activity 2A: Candlemaking—Dipped Candle

Caution: An adult will need to help you with this activity.

Candles have been a light source in homes for a long time. In this activity, you can make a dipped candle.

What you need

- water
- a stovetop
- a saucepan
- paraffin wax or candle stubs
- 2 empty tin cans, each about 15 cm tall
- wax crayons (optional, for colour)
- heavy cotton string for a candlewick (or candlewicking)
- a thin stick (a bamboo skewer, pencil, chopstick, ice-treat stick, or thin twig)
- 2 cereal boxes (or similar objects that can be used to suspend the candle)

What to do

1. Break or cut the wax into chunks and put the pieces into one of the metal cans. Drop one crayon into the wax (optional).

2. Pour water into the saucepan to a depth of about 3 cm. Place the can into the saucepan. Heat the water until the wax melts. The depth of the melted wax will be the height of the candle. If you want a taller candle, you can add more wax pieces when the first pieces melt.

3. Fill the second can with cold water. You will be dipping the candle into this water.

4. Cut the wick (the cotton string or candlewicking) the height of the cans plus 15 cm. Tie one end of the wick around the middle of the thin stick.

5. Hold the thin stick and dip the wick into the melted wax. Wait for 90 seconds. (Count slowly to 90.)

6. Lift up the wick from the wax. Allow the wax to stop dripping. Dip the waxed wick in the can of cold water.

7. Dip the wick into the melted wax again—this time for 3 seconds. Remove the wick and dip it in the cold water.

8. Repeat Step 7.

9. Continue dipping the wick for 3 seconds at a time. Dip the wick in the cold water after each time in the wax.

10. Keep dipping the wick until the bottom of the candle measures 2 cm across.

11. Suspend the candle between the cereal boxes.

12. Turn off the heat. Remove the can of wax and saucepan from the stove.

13. Let the candle hang until it hardens completely. When it is hardened, you can trim your candle's wick to about 1 cm.

Do **NOT** use candles without adult supervision. Put out any candle when you leave a room.

Activity 2B: Candlemaking—Sand Candle

Caution: An adult will need to help you with this activity.

In this activity, you will make a sand candle.

What you need

- a saucepan
- water
- a stovetop
- oven mitts
- moist sand
- a thin stick*
- paraffin wax or candle stubs
- 2 empty tin cans, each about 15 cm tall
- wax crayons (optional, for colour)
- a plastic container that can be recycled**
- heavy cotton string or candlewicking
- pebbles, shells, or beads (optional)

* A bamboo skewer, pencil, chopstick, ice-treat stick, or thin twig may be used.

** A margarine, sour cream, or yogurt container may be used.

What to do

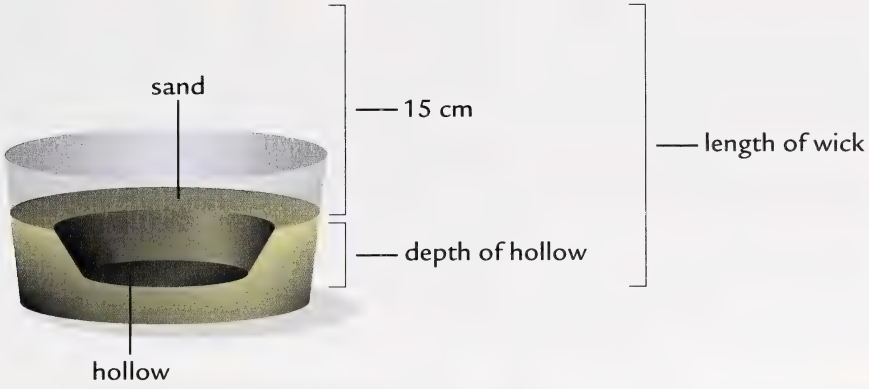
1. Break or cut the wax into chunks and put them into one of the metal cans. Add a wax crayon if you want a coloured candle.

2. Put water into the saucepan to a depth of about 3 cm. Place the can into the saucepan. Heat the water until the wax melts.

3. Fill the margarine container with moist sand. Make a hollow in the sand. This hollow is where the candle will be made.

4. Place pebbles, shells, or beads in the sides of the hollow. These will stick to the sides of the candle.

5. Cut the wick the depth of the hollow plus 15 cm. Tie one end of the wick to the thin stick and knot the other end.



6. Dip the knotted end of the wick into the hot wax to stiffen it. Let the wick cool before handling it.

7. Bury the knot in the sand in the bottom of the hollow. Try to put the wick close to the centre of the hollow.

8. Lay the stick across the top of the container. Roll the stick until the wick is straight and centred. Do not pull too much!

9. Turn off the heat. Remove the saucepan from the burner.

10. Using oven mitts, carefully lift the can of wax out of the saucepan. Slowly pour a little hot wax into the bottom of the hollow to hold the wick down. Wait until this wax hardens a bit (it looks cloudy when it hardens).

11. Slowly pour wax into the hollow until the top of the sand is reached.

12. Place the container in a place where it will not be disturbed. Let the candle sit overnight. Carefully lift the candle out of the sand. Gently brush off any loose sand. Trim the candle's wick to about 1 cm.

Do NOT use candles without adult supervision. Put out any candle when you leave a room.

Section 2

Exploring Shadows

Introduction

In Section 1, you found out that light travels straight out from its source. But you looked mostly at what happened in front of the object. If something blocks light from its straight path, what happens behind the blocker?

A shadow forms! Did you guess right?

In this section, you will explore how shadows form. You will study how the shadows made by sunlight change over a day. You will also experiment to see how moving lights and objects changes the shadows cast. Have fun with shadows!

Lesson 5: Sun Shadows

It's a treat to find a cool shady spot on a hot summer day. If you sit for a long time, you may have to move to stay in the shade. Why do you have to move? In this lesson, you will find out about the shadows made by the Sun.

Shady spots are shadows made by objects as they block the Sun's rays before they hit the ground.

At what time of day is it hardest to find shade? When is it easiest to find shade? If you don't already know, today's activity will help you find out.

Sun shadows act in the same way as the shadows made by other light sources. Have fun seeing how Sun shadows change as Earth moves.

Activity 5A: Making Predictions by Using a Flashlight

What you need

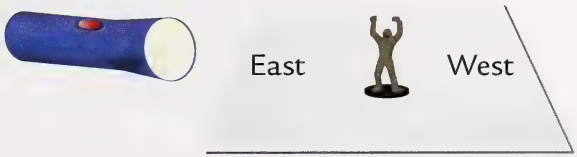
- a flashlight
- a small toy (about 3 cm high)
- a sheet of paper
- a pencil
- a helper
- a dark room

What to do

This part needs to be done in a dark room. Ask your home instructor for help with this activity.

1. Place the toy in the middle of the piece of paper. Draw an outline around the bottom of the toy. This will show you where the toy was.

2. Mark one side of the paper "west" and the opposite side "east."



3. Shine the flashlight on the toy from the east point. This is like the Sun rising in the east.

   a. Where is the toy's shadow when the Sun rises?

   _____

   _____

   b. Is the toy's shadow long or short?

   _____

   c. Draw around the toy's shadow on the paper. Label it "morning shadow."

4. Move the flashlight (the Sun) across the sky. Put it directly above the toy and shining down on it. This shows noon. Noon is the time when the Sun is at its highest point in the sky.

   a. Where is the toy's shadow at noon?

   _____

   _____

b. Is the toy's shadow long or short?

_____

c. Draw around the toy's shadow on the paper. Label it "noon shadow."

5. Move the flashlight (the Sun) across the sky until it is about to set at the "west" side of the paper.

a. Where is the toy's shadow when the Sun sets?

_____

_____

b. Is the toy's shadow long or short?

_____

c. Draw around the toy's shadow on the paper. Label it "evening shadow."

6. In Activity 5B, you will measure your shadow at different times of the day. Think about the toy's shadow when you answer these questions.

a. When will your shadow be the longest?

_____

_____

b. When will your shadow be the shortest?

_____

_____

c. What time of day will have the least amount of shade?

_____

_____

Check your answers for this activity in the Suggested Answers at the end of this lesson.

Activity 5B: Measuring Sun Shadows

What you need

- a sunny day
- a pen or pencil
- a piece of paper (or a notebook)
- coloured chalk (6 different colours)
- an outside place where you can draw on the ground (a concrete pad or pavement) or a big piece of cardboard or craft paper

What to do

7. Start this part of the activity as soon after the Sun rises as you can. You need a sunny day to do this activity. A sunny day will give you clear shadows for tracing.

Ask your home instructor to help you with this activity.

8. Choose a spot outside that will not be in shade during the day. Try to find a place with concrete or pavement on the ground. (You can use a big piece of cardboard or craft paper on the ground instead.) Your helper will trace your shadow using the coloured chalk.

9. Stand in the middle of the area you have chosen. Turn your back to the Sun.

10. Trace the outline of your feet with chalk. This marks where you will stand for each shadow tracing.

11. Stand up as straight as you can. Ask your helper to trace the outline of your shadow with chalk.

12. On your paper or in your notebook, write down the time of day and the colour of chalk used.

13. Take shadow tracings at least five other times during the day. Use a different colour chalk for each shadow. Stand in the same spot and ask your helper to outline your shadow.

    Try to space your trials evenly through the day. One should be at or close to noon. Another should be at or close to sunset.

14. For each tracing, write down the time of day and the colour of chalk used.

15. Compare your shadows at the end of the activity. Answer these questions.

a. When was your shadow the longest?

_____

_____

b. When was your shadow the shortest?

_____

c. What time of day had the least amount of shade?

_____

_____

16. Do the answers for this activity match your predictions in question 6, Activity 5A? Explain.

_____

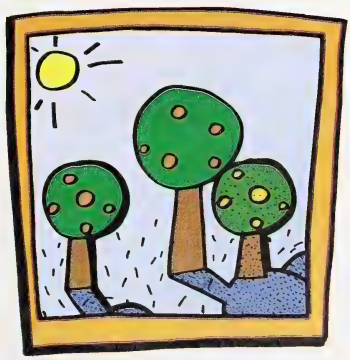
_____

_____

_____

Check your answers for this activity in the Suggested Answers at the end of this lesson.

Sun shadows change shape and location as the day passes. Why? Earth rotates around its axis once a day. You see this as the Sun moving across the sky. When a light source moves, the shadows it makes change. Shadows made by the Sun behave in the same way that other shadows do.



Enjoy a shady spot on the next sunny summer day as you think about the science of Sun shadows!

Turn to Assignment Booklet 3A and complete question 5 of the Section 2 Assignment.

A CLOSER LOOK

A Sundial

For centuries the Sun and the shadows it created were the best way to tell time. The illustration shows one simple looking time-telling machine, the sundial.

Designers of sundials use geometry and knowledge about where the sundial will be placed. A well-designed sundial tells time quite accurately. Look closely at the illustration. Where do you think you would read the time? Most sundials have numbers around the edge. They have a raised metal shape that casts a shadow. You use the shadow's position to find the time.

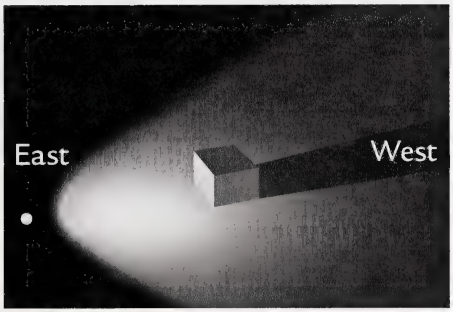
Do you think you'd like to make a sundial? Visit this website for directions.

http://liftoff.msfc.nasa.gov/Academy/Earth/Sundial/Sundial-ConstructSimple.html

Suggested Answers

Activity 5A: Making Predictions by Using a Flashlight

3. a. Where is the toy's shadow when the Sun rises?

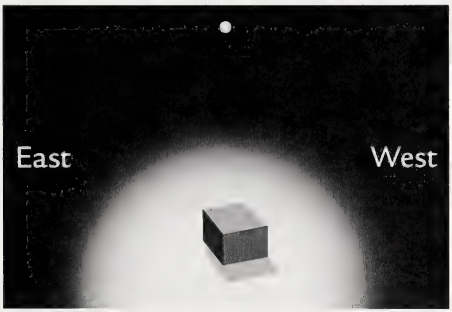


The toy's shadow will be on the "west" side of the paper.

b. Is the toy's shadow long or short?

The toy's shadow will be long at sunrise.

4. a. Where is the toy's shadow at noon?



The toy's shadow at noon will be on the "north" side of the paper.

b. Is the toy's shadow long or short?

The toy's shadow is short at noon.

5. a. Where is the toy's shadow when the Sun sets?

The toy's shadow will be on the "east" side of the paper.

b. Is the toy's shadow long or short?

The toy's shadow will be long at sunset.

6. a. When will your shadow be the longest?

Your shadow should be the longest at sunrise and sunset.

b. When will your shadow be the shortest?

Your shadow should be the shortest at noon.

c. What time of day will have the least amount of shade?

Noon has the least amount of shade. Shadows cast by objects are the shortest at noon.

Activity 5B: Measuring Sun Shadows

15. a. When was your shadow the longest?

Shadows are longest at sunrise and sunset.

b. When was your shadow the shortest?

Shadows are the shortest at noon.

c. What time of day had the least amount of shade?

Noon had the least amount of shade. Shadows cast by objects are the shortest at noon.

16. Do the answers for this activity match your answers in question 6, Activity 5A? Explain.

Answers will vary. Were you a good predictor?

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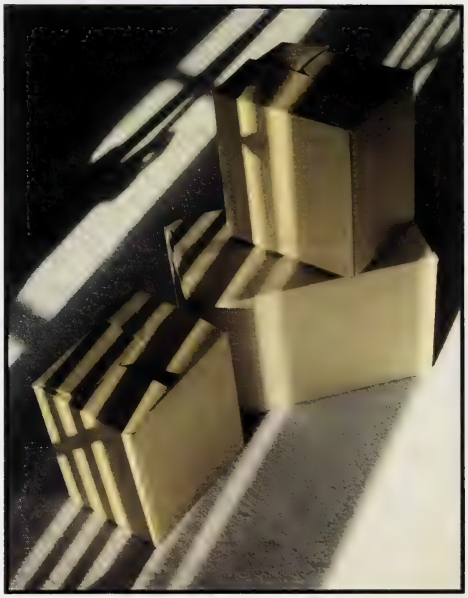
Lesson 6: Shadow Shape

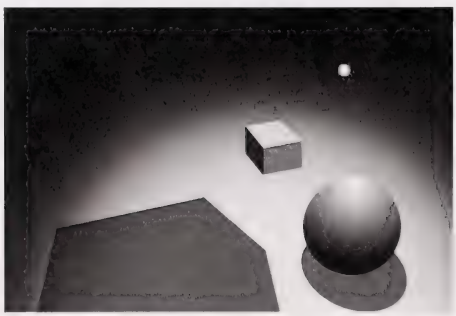
How do shadows change? Today you will have fun shaping shadows!
A shadow is an area of darkness caused when an object blocks the path of light.



There are shadows all around you. If there is light coming from more than one source in a room, shadows may be very light. Shadows can show up on any surface, such as a floor, ceiling, or wall. Look at the walls in the room around you. Can you see the shadows made by things in the room?

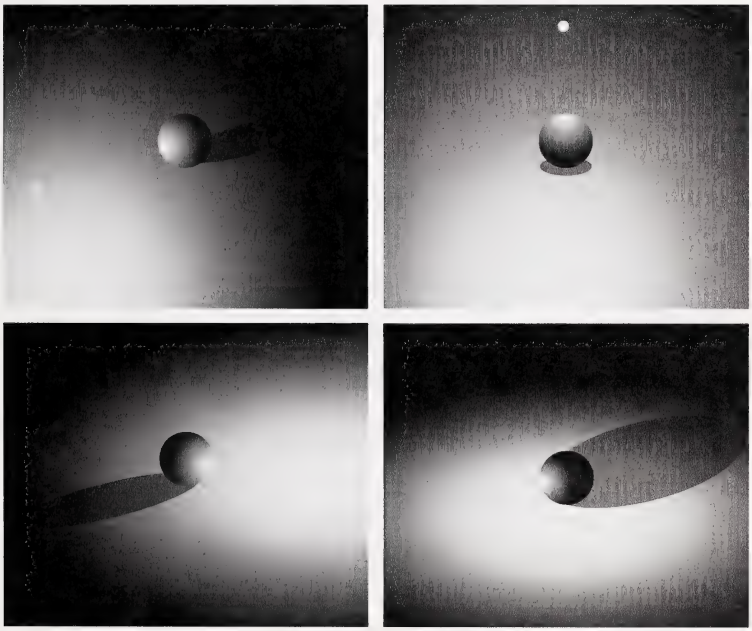
Shadows are not always the same size or shape as the object that makes them.

Small objects can cast big shadows.



Short objects can cast long shadows.

The same object can make a tall, short, skinny, or fat shadow.



How do shadows change? Do Activity 6: Exploring Shadows to find out!

Activity 6: Exploring Shadows

In this activity, you will explore the location, size, and shape of shadows.

What you need

- an empty, rinsed 1-L milk carton
- a dark room
- an open floor area
- a flashlight
- a helper
- a piece of white paper, about 2 m × 1 m
- a metre-stick (or a measuring tape or a ruler)
- a red pencil or pencil crayon

Ask your home instructor to help you with this activity.

What to do

1. Measure the height and width (in centimetres) of your milk carton.

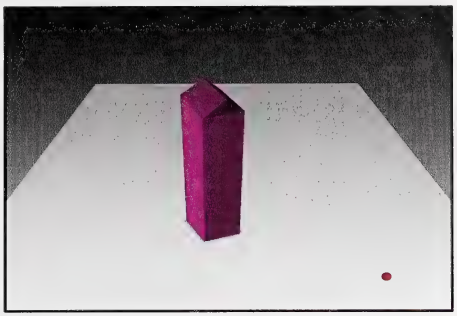
   Height of the carton: _____ cm

   Length of both sides of the carton: _____ cm

2. Cover the floor with the large piece of white paper. If you have only small pieces of paper, tape them together to form one large sheet.

3. Place an X in the middle of the paper. Use the method you used in Section 1: Activity 4 to find the centre. Set your carton on top of the X.

4. Put a red mark on the paper to one side of the carton.



Turn off the lights in your room.

5. Put your flashlight above the red mark on the paper. Shine the flashlight toward the centre of your carton. A shadow will form. Have your helper find the end of the shadow and mark it with a red "o" on the white paper.

6. Turn on the light and move the carton off the X.

7. Draw a red line between the two red marks.

8. What do you notice about the line you drew in Step 7?

_____

_____

_____

9. Where do shadows form?

_____

_____

_____

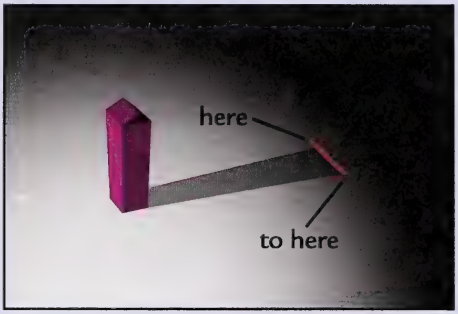
Measuring Hints

Finding the length of a shadow

- Make a mark at the end of the shadow.
- Remove the carton.
- Measure between the X and the mark on the paper.

Finding the width of a shadow

- Measure the width of the end of the shadow.



10. Put the carton back on the X. Move the flashlight around the carton. To answer the next questions, you'll have to find just the right spot.

11. a. Make the longest shadow that fits on the paper.

How long is the shadow? _____ cm

b. Where did you hold the flashlight?

_____

_____

12. a. Make the shortest shadow you can. How long is the shadow? _____ cm

b. Where did you hold the flashlight?

_____

_____

13. a. Make the fattest (widest) shadow you can. How wide is the shadow? _____ cm

b. Where did you hold the flashlight?

_____

_____

14. a. Make the thinnest shadow you can. How wide is the shadow? _____ cm

b. Where did you hold the flashlight?

_____

_____

15. Try to make the shadow the same length as your carton's height. Where did you hold the flashlight? You may draw a diagram to help explain your answer.

_____

_____

_____

Check your answers for this activity in the Suggested Answers at the end of this lesson.

Shadows can be short, long, skinny, or fat (wide). In this lesson, you discovered the following:

- Short shadows are created when the light source is high above the object.

  This statement is true for shadows at noon. The Sun is at its highest point at noon so it makes your shadow very short.

- Long shadows are created when the light source is at the same height as the object or at the base (bottom) of a tall object.

  This statement is true for shadows at sunrise and sunset. The Sun is at its lowest points at these times. This makes your shadow very long.

- Skinny shadows are created when the light source is far away from the object.

- Fat (wide) shadows are created when the light source is close to the object.

Turn to Assignment Booklet 3A and complete question 6 of the Section 2 Assignment.

Suggested Answers

Activity 6: Exploring Shadows

1. Measure the height and width (in centimetres) of your milk carton.

Answers will vary. Sample answers are given.

Height of the carton: **23.5** cm
Length of both sides of the carton: **7** cm

8. What do you notice about the line you drew in Step 7?

It is a straight line. It joins the mark at the end of the shadow to the mark for the flashlight. It also passes through the X the carton sits on.

9. Where do shadows form?

Shadows form where an object blocks light. The end of the shadow, the object, and the light are in a straight line. The object is between the light and the shadow.

For questions 12 to 16, answers will vary. Sample answers are given.

11. a. Make the longest shadow you can. How long is the shadow?

The shadow was **95** cm long.

b. Where did you hold the flashlight?

You likely held the flashlight close to the floor near the edge of the paper.

12. a. Make the shortest shadow you can. How long is the shadow?

The shadow was **1** cm long.

b. Where did you hold the flashlight?

You likely held the flashlight high above the carton directly over its top.

13. a. Make the fattest (widest) shadow you can. How wide is the shadow?

The shadow was **20** cm wide.

b. Where did you hold the flashlight?

You likely held the flashlight very close to the carton.

14. a. Make the thinnest shadow you can. How wide is the shadow?

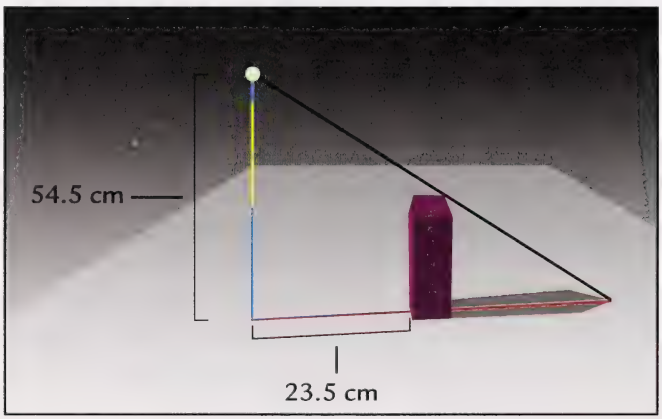
The shadow was **7.5** cm wide.

b. Where did you hold the flashlight?

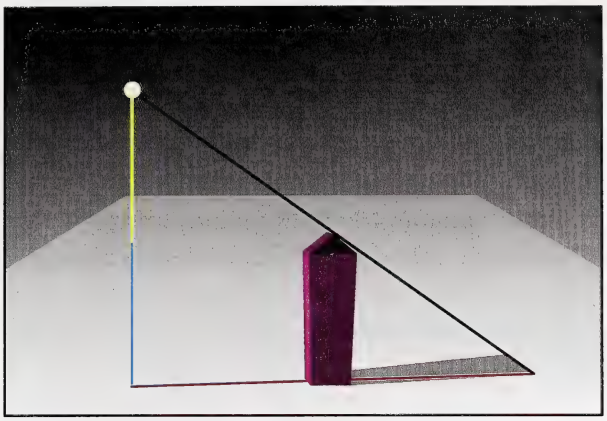
I held the flashlight far away from the carton.

15. Try to make the shadow the same length as your carton's height.

The sketch shows that the flashlight was held about 54.5 cm above the base of the carton. This is a bit more than twice the height of the carton. It was held about 23.5 cm away from the carton. This is the height of the carton.



You may have placed the carton differently. The measurements would be different.



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Lesson 7: Moving the Source

In this lesson, you will look more closely at how a shadow changes when you move the light source. A simple shadow play is about to begin!

A CLOSER LOOK — Shadow Puppets

Using shadows and puppets to tell stories is a very old art. The puppets used in China and other Asian countries are very complex. They have coloured parts and moving parts.

Would like to know more about shadow puppets? These websites will give you ideas for putting on an exciting show.

http://www.osv.org/kids/crafts2.htm

http://www.magicalmoonshine.org/shadow.htm

Activity 7: Shadow Play

You and your helpers
get to play with shadows.
Watch closely to see what
moves and what you see on the screen!

Ask two people to help you with this activity.

What you need

- a puppet*
- a screen**
- an opening for the screen***
- a small lamp with no lampshade
- 2 helpers
- a tape measure or metre-stick
- tape, duct tape, or pushpins

* You can use the puppet you made in Section 1: Activity 3 or make a new or additional puppet.

** Use a white bed sheet or large piece of white paper (craft paper from rolls used to cover tables) for a screen.

*** Use an opening (a doorway, for example) that you can drape (hang) the sheet across. You will also need a way to fasten the sheet (duct tape or pushpins).

What to do

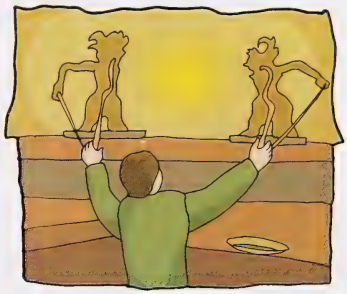
1. Choose an opening for your screen (the sheet or paper). The puppeteer and light source must fit behind the screen. You have to be able to sit in front of the screen. You must be able to darken the room around the opening.

2. Drape the sheet or paper across the opening you have chosen. Ask your home instructor to fasten the sheet so it will not fall down. Duct tape works well, but it should be used with care around painted walls. Pushpins can be used.

3. Place the light source about 2 m behind the sheet.

4. Locate your puppet from Section 1 or make a new puppet.

5. One of your helpers will be the puppeteer. The puppeteer will place the puppet between the sheet and the light source.



6. Your other helper will move the lamp. Copy the following list on a piece of paper for this person. The list shows how he or she should move the light.

Move Number	Direction Light Moved
	(helper's) right
	(helper's) left
	toward the puppet
	away from the puppet

7. The lamp mover must mix up the order of the directions on the list. This information will be kept secret from you. Have the lamp mover write the mixed up numbers on his or her copy of the chart. You will get to see it later.

8. Darken the room you are in. Sit down about 2 m in front of the sheet to watch the shadow.

9. The lamp mover should start by placing the light about 1 m behind the sheet. The puppeteer will hold the puppet halfway between the light and the screen. The puppeteer must keep the puppet in the same place during this activity.

   The lamp mover will move the light in the order he or she chose in Step 7. After each move, the lamp mover will wait for you to do the next step (Step 10). Ask your helper to continue when you have completed your observations.

10. After the lamp mover moves the light, record what you see. Use the following chart. Decide which direction the lamp moved during each move. Explain what you saw in each move. It will help you decide how the light was moved.

Move Number	What did you see?	Direction Light Moved
1		
2		
3		
4		

11. Now you get to see the secret chart. Compare the order you guessed with the order that the lamp mover chose. Were there any differences? Explain.

You may ask your home instructor for help with this question.

_____

_____

_____

12. As a light source moves to the left or right, what happens to the shadow?

13. As a light source moves toward an object, what happens to the shadow?

14. As a light source moves away from an object, what happens to the shadow?

Check your answers for this activity in the Suggested Answers at the end of this lesson.

Your shadow play in the activity showed the following:

- You see small shadows when the object is near the surface (the screen or place where the shadow falls), or when the light source is far away from the object.

- You see large shadows when the object is far away from the surface or when the light source is close to the object.

- When you move a light source to the left or right, its shadow moves the opposite way.

  This statement is true for how the directions of Sun shadows change. As the Sun seems to move from east to west, your shadow moves in the opposite direction. It moves from west to east.

On Earth, the most important light source is the Sun. You have seen how you cast a shadow when the Sun shines on you. There are some things that don't seem to cast a shadow. You will find out more about this in the next lesson.

Turn to Assignment Booklet 3A and complete question 7 of the Section 2 Assignment.

Suggested Answers

Activity 7: Shadow Play

10. After the lamp is moved, record what you see. Decide which direction the lamp moved during each move. Explain what you saw in each move. It will help you decide how the light was moved.

Move Number	What did you see?	Direction Light Moved
1	The shadow moved left.	right
2	The shadow moved right.	left
3	The shadow got bigger.	toward the puppet
4	The shadow got smaller.	away from the puppet

11. Now you get to see the secret chart. Compare the order you guessed with the order that the lamp mover chose. Were there any differences? Explain.

Answers will vary. Your guesses may or may not have been right. If they were all correct, congratulations! You understand how shadows change when you move the source of light. If you had some guesses wrong, you may want to repeat the activity.

12. As a light source moves to the left or right, what happens to the shadow?

The shadow moves in the opposite direction that the light moves.

13. As a light source moves toward an object, what happens to the shadow?

As the light source moves toward an object, the shadow gets bigger.

14. As a light source moves away from an object, what happens to the shadow?

As the light source moves away from an object, the shadow gets smaller.

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Lesson 8: Transparent, Translucent, and Opaque

One problem with vehicle windshields is that they crack and break quite easily. Why isn't granite rock used instead? Wouldn't that make more sense? Granite doesn't crack or break nearly as easily as glass. What would the new problem be if rock was used for windshields? Drivers wouldn't be able to see!

There are some things you can see through, some things you can partially see through, and others you cannot see through. In this lesson, you will explore the differences among these materials.

Transparent Objects

transparent: allowing most light to travel through

Almost all light passes through **transparent** objects. These objects are **see-through**.

The following objects are transparent.

Can you think of other examples of transparent objects?

Translucent Objects

Some light passes through a translucent object. The light is scattered as it passes through. You are not able to see a clear picture through a **translucent** object.

translucent: allowing some light to pass through but not enough for clear images

The following objects are translucent.

Can you think of other examples of translucent objects?

Opaque Objects

No light passes through an opaque object. These objects are NOT see-through.

The following objects are opaque.

Can you think of other examples of opaque objects?

Activity 8: How Much Light?

In this activity, you will find and classify things in your home as transparent, opaque, or translucent.

Do NOT use the Sun as your light source. Looking directly at the Sun can cause eye damage!

What you need

- objects to test from around your home
- a light source, such as a small lamp or a ceiling light

What to do

1. Answer the following questions before you begin this activity.

   a. What kind of material lets most light pass through it?

   _____

   b. What kind of material lets no light pass through it?

   _____

   c. What kind of material lets some light pass through it?

   _____

2. To test each object, hold it between your eyes and your light source. Ask yourself how much light passes through the object.

3. Classify each object as transparent, translucent, or opaque. Fill in the following chart. Your challenge is to try to find at least three examples of each type of object.

Transparent	Translucent	Opaque

Check your answers for this activity in the Suggested Answers at the end of this lesson.

The most common transparent material is glass. Glass is used for making jars and bottles, eyeglasses, windows in appliances and vehicles, bakeware, glasses, and measuring cups.

In your home, your windows are likely made of glass.

Glass lets you see in and out, yet it doesn't let air move in and out of your home. The following website tells about the history of glass:

http://www.historyforkids.org/learn/science/glass.htm

Before glass was affordable, other ways of letting in light were used. Take "A Closer Look" at windows of the past.

Windows of the Past

Try this simple activity. On a piece of white paper draw a house with doors and windows. Rub cooking oil over the spots where the windows are. Hold your piece of paper up to the light. What do you see? The windows are letting some light through—they are now translucent!

In the past, people made translucent windows by rubbing oil onto animal skins. These animal skins were stretched over the window openings in their walls. The windows let in some daylight because they were translucent. The windows kept out bad weather because they were made of animal skin.

Translucent materials are often used to soften harsh light sources. Lampshades allow enough light through to let you see things in a room. The light is no longer shining directly on things. The shadows become less distinct. The lighting is softer than a bare bulb lighting up a room.

If you look around you, opaque objects seem to be the most common type of object. Opaque objects stop light and make shadows.

Turn to Assignment Booklet 3A and complete question 8 of the Section 2 Assignment.

Suggested Answers

Activity 8: How Much Light?

1. a. What kind of material lets most light pass through it?

A transparent material allows most light to pass through it. Examples are clear glass or plastic.

b. What kind of material lets no light pass through it?

An opaque material lets no light pass through it. Examples are wood and metal.

c. What kind of material lets some light pass through it?

A translucent material allows some light to pass through it. Examples are coloured glass and lightweight cloth.

3. Classify each object as transparent, translucent, or opaque. Fill in the following chart. Your challenge is to try to find at least three examples of each type of object.

Answers will vary. The following are examples of objects you may have tested.

Transparent	Translucent	Opaque
clear glass bottle	wax paper	action figure toy
sandwich bag	shower door	running shoe
clear drinking glass	looseleaf paper	cupboard door
clear plastic berry basket	tissue paper	tin can

Key Words

translucent: allowing some light to pass through, but not enough for clear images

transparent: allowing most light to travel through

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Section 2

Conclusion

You have seen shadows and how they form and change. You experimented by moving lights and objects. You saw how each changed the shadows.

When you look at the world now, remember that you can see it because of the way that light travels and bounces.

Now fill out the Student Feedback Form and the Checklist for Section 1 and Section 2 in Assignment Booklet 3A. Make sure you have collected everything to send to your teacher.

Optional Follow-up Activities

Activity 1: Your Local UV Rating

The UV (ultraviolet) rating for an area tells how strong the Sun's rays are on a given day. The lower the number, the less risk there is of getting a sunburn. The following is a description of the UV index.

UV Index	Description	What Does This Mean?
0–2	low	· Minimal sun protection is required for normal activity. · Wear sunglasses on bright days. If you will be outside for more than 1 hour, cover up and use sunscreen. · Reflection off snow can nearly double UV strength. Wear sunglasses and apply sunscreen.
3–5	moderate	· Take precautions—cover up and wear a hat, sunglasses, and sunscreen—especially if you will be outside for 30 minutes or more. · Look for shade near midday when the sun is strongest.
6–7	high	· Protection is required. UV damages the skin and can cause sunburn. · Reduce time in the sun between 11 a.m. and 4 p.m. Take full precautions—seek shade; cover up; and wear a hat, sunglasses, and sunscreen.
8–10	very high	· Extra precautions are required; unprotected skin will be damaged and can burn quickly. · Avoid the sun between 11 a.m. and 4 p.m. Take full precautions: seek shade; cover up; and wear a hat, sunglasses, and sunscreen.
11+	extreme	· Values of 11 or more are very rare in Canada. · Take full precautions. Unprotected skin will be damaged and can burn in minutes. Avoid the sun between 11 a.m. and 4 p.m.; cover up, and wear a hat, sunglasses, and sunscreen. · White sand and other bright surfaces reflect UV and increase UV exposure.

What you need

- a pen or pencil
- looseleaf paper
- a newspaper that lists the UV rating for your area, access to a weather channel or local weather report, or access to Environment Canada's website

http://www.ec.gc.ca/

At this website, choose "Weather" and then go to the "Text Forecasts." You will find a link to "Daily UV Forecast for Major Canadian Cities." Find the city nearest you on this listing.

What to do

1. On looseleaf paper, make a chart with these headings.

Date	UV Rating	Type of Protection Needed

2. Find out what your local UV rating is each day for 2 weeks. Record these ratings on your chart.
3. Use the UV index chart to find out the type of protection you need if you want to be outdoors. Record this information in the chart.
4. You may wish to post your chart where family members can use it.

Activity 2: How Big Is the Sun?

Believe it or not, the Sun is just an average-sized star. Even so, it is MUCH larger than Earth. In this activity, you will find out just how big a light source the Sun is!

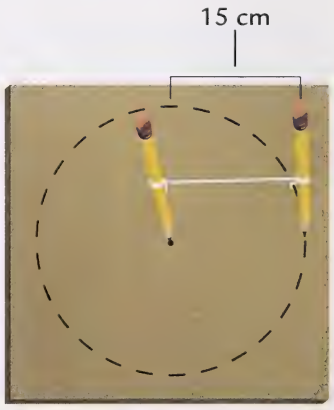
Ask your home instructor for help with this activity.

What you need

- scissors
- string
- a ruler
- 2 pencils or pens
- 2 pieces of lightweight cardboard (30 cm × 30 cm)
- 3 wooden skewers (or chopsticks or thin dowels)
- a large open area, such as a park or school yard

What to do

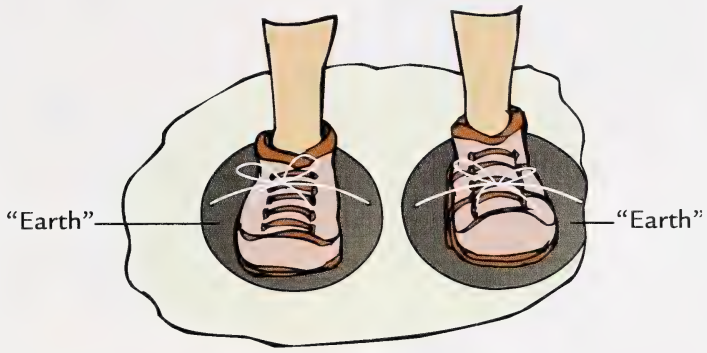
1. Make a cardboard circle with a diameter of 30 cm. To do this, poke a small hole in the centre of a piece of cardboard. Place the pointed end of a pen or pencil into the hole. Tie one end of a piece of string to this pen. Tie the other end of the string to another pen or pencil so that the string between the pens is 15 cm long. Use the second pen to draw a circle on the cardboard. Cut out the circle.



   The diameter (distance across the middle) of the circle is 30 cm.

2. Use the first circle to trace a second cardboard circle of the same size. Cut out this circle. Each circle represents Earth.

3. Poke holes across from each other into the edge of each cardboard circle. Thread string through these holes. Use the string to tie the circles onto your shoes (with your feet in them!).



4. Go outside. Push a skewer into the ground at one end of your open area. This will be the edge of your Sun.

5. Walk 55 steps in a straight line, keeping one Earth touching the next Earth as you walk. This means that you will put your right foot down, and to make the next step, you will put the back edge of your left-foot Earth against the front edge of your right-foot Earth. This is called heel-to-toe walking, or Earth-to-Earth walking!

6. Push a second skewer in the ground after you have taken 55 Earth steps. This is the centre of your Sun.

7. In the same manner as in Step 5, walk another 55 heel-to-toe steps in the same straight line.

8. Push a third skewer into the ground after you have walked the 55 steps. This is the other edge of your Sun.

9. Look at the size of the Earth on the bottom of one foot. Compare it with the size of the Sun. What do you notice?

10. Write a paragraph about what you observed. Send it to your teacher.

Activity 3: Using a Watch Compass

Watches tell time, but did you know that a watch can help you find a direction?

What you need

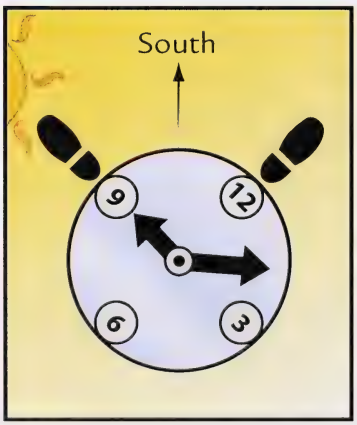
- a sunny day
- a compass
- a watch with an hour hand and numbers on each hour

What to do

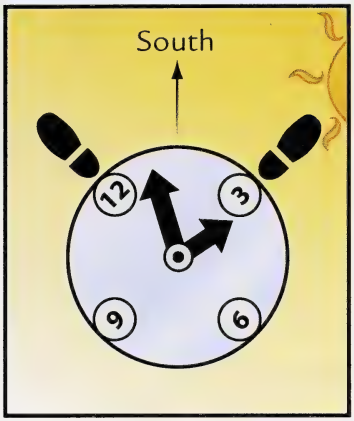
1. Point the hour hand of your watch toward the Sun. You know that you have it lined up correctly if the shadow cast by the hour hand is right under the hour hand itself.

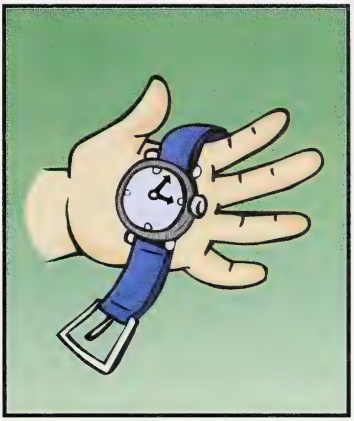
2. Keep the hour hand of your watch pointed toward the Sun.

   a. **In the morning:** Point your left foot toward the Sun. Point your right foot the way 12 on your watch is pointed. You will be facing south.



b. **In the afternoon:** Point your right foot toward the Sun. Point your left foot the way 12 on your watch is pointed. You will be facing south.





3. You have found south using your watch.

4. Find south using the compass.

5. Compare the directions found using both types of compasses.

Note: To be accurate, a watch compass should use Sun time. You can get fair results using Standard Time. Daylight-Saving Time causes more error problems.

If Daylight-Saving Time is in use, turn your watch back one hour. (Remember to turn it ahead when you have finished the activity.)

Activity 4: Canada's Time Zones

Find out more about Canada's time zones and daylight-saving time by going to the following website.

http://www.canadainfolink.ca/time.htm

Section 3

Twisting, Bouncing, and Breaking Up

Introduction

So far, you have explored how light is created. You can answer the question, "Why can you see through glass, but not concrete?" There are so many questions that you still haven't answered! Here are some examples:

- How can you see light from a star billions of kilometres away?
- How do glasses help you see?
- How many colours of light are there?

The light that is created by the Sun, light bulbs, or candles is called white light. In this section, you will split white light into colours. How can white light be made up of coloured light? As well, you get to mix coloured light to make white light!

Lesson 9: Changing Directions

Have you ever been at a carnival and played on the bumper cars?

Imagine that you are driving in a straight line. If you smash into another bumper car, what might happen? You might bounce back, or you might glance off the other car and change your direction a bit. If you were a beam of light, bouncing back would mean you were reflected. Glancing off an object would mean that your path was bent.

glance: hit and move off at a slant

Opaque objects change the path of light by absorbing or reflecting it. Light reflected to your eye lets you see the object.

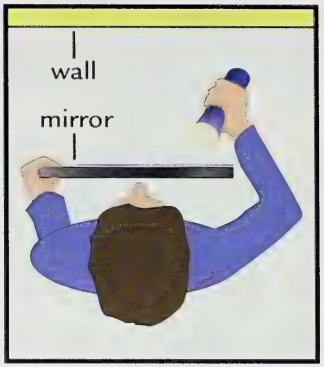
Activity 9A: Reflection

Try this simple experiment to see how an object can reflect light.

What you need

- a flashlight
- a small mirror
- a dark room

What to do



1. Take the small mirror and flashlight into a dark room.

2. Stand in front of a wall. Hold the mirror in front of you, with the shiny front facing away from you.

3. Shine the flashlight toward yourself onto the mirror. What do you see?

_____

_____

4. Move the flashlight back and forth so the light beam hits the mirror at different angles. Keep the mirror steady. What happens to the light beam on the wall?

_____

_____

_____

5. Move the mirror back and forth and keep the flashlight steady. What happens to the light beam on the wall?

_____

_____

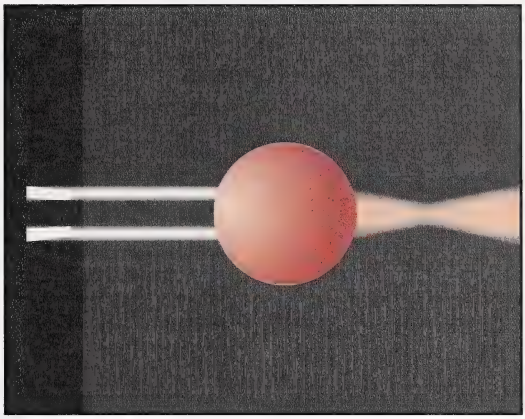
_____

Check your answers for this activity in the Suggested Answers at the end of this lesson.

The mirror is an opaque object. It reflects light.

Transparent objects allow light to pass through them. Some transparent objects bend the light. Some objects bend only one colour of light and absorb the rest.

Light enters through small slots. It passes through a red glass ball. It is bent. (The red ball absorbs everything except the red light.)



refraction: the bending of light as it passes through a transparent object

This bending of light is called **refraction**. When light bends, objects will look larger, smaller, or crooked.

Activity 9B: Refraction

Do you think you can use a drop of water to change the way you see words on a page? You will find out in this activity.

What you need

- water
- a piece of clear plastic wrap
- a piece of paper with small printing on it, such as a newspaper

What to do

6. Hold the plastic wrap over the printing and observe the letters.

7. Place a drop of water onto the plastic wrap.

8. Hold the plastic wrap over the printing and observe the letters through the water droplet.

9. What do you notice about the letters seen through the water droplet?

_____

_____

_____

10. Move the plastic wrap closer to and farther from the paper. What happens to the size of the letters as you move the plastic wrap?

_____

_____

_____

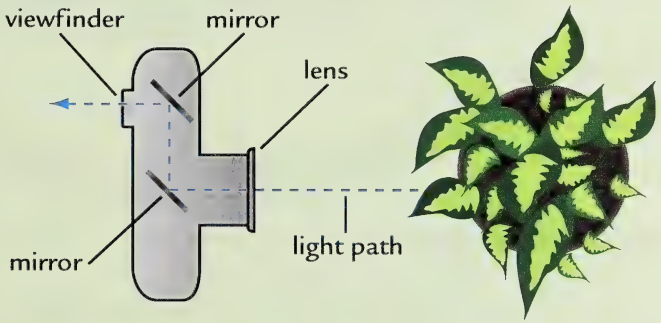
Check your answers for this activity in the Suggested Answers at the end of this lesson.

You have seen how light can be reflected. You have also looked at how light can be refracted or bent. Some cameras change the direction of light in both ways.

Take "A Closer Look" at how some cameras work.

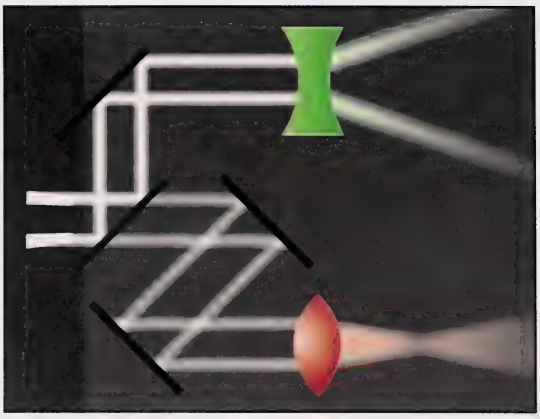
Cameras: Reflecting and Refracting

Some cameras change the direction of light in two ways. The glass lens bends (refracts) the light and makes a small image.



After passing through the lens the light may hit a mirror. The mirror reflects the light into the viewfinder. The person who is taking the picture sees exactly how the picture will look. The camera looks after getting the mirror out of the way when a picture is taken.

Look at the picture at the right and find the mirrors and lenses. What happens to the light that passes through the openings on the left?



The picture shows four mirrors and two coloured lenses.

The first mirror reflects some of the light and lets some pass through. The other mirrors reflect the light that hits them. The green lens bends green light. This lens spreads apart the green light. The red lens bends red light. This lens focuses the red light.

Remember that light travels in a straight line until something changes its path. Opaque objects absorb or reflect light. Transparent objects can bend light. You will discover more about refraction and reflection of light in the next few lessons.

Turn to Assignment Booklet 3B and complete question 9 of the Section 3 Assignment.

Suggested Answers

Activity 9A: Reflection

3. Shine the flashlight toward yourself onto the mirror. What do you see?

A beam of light shows up on the wall of the dark room.

4. Move the flashlight back and forth so the light beam hits the mirror at different angles. Keep the mirror steady. What happens to the light beam on the wall?

The light beam moves across the wall as the flashlight is moved.

5. Move the mirror back and forth and keep the flashlight steady. What happens to the light beam on the wall?

The light beam moves across the wall as the mirror is moved.

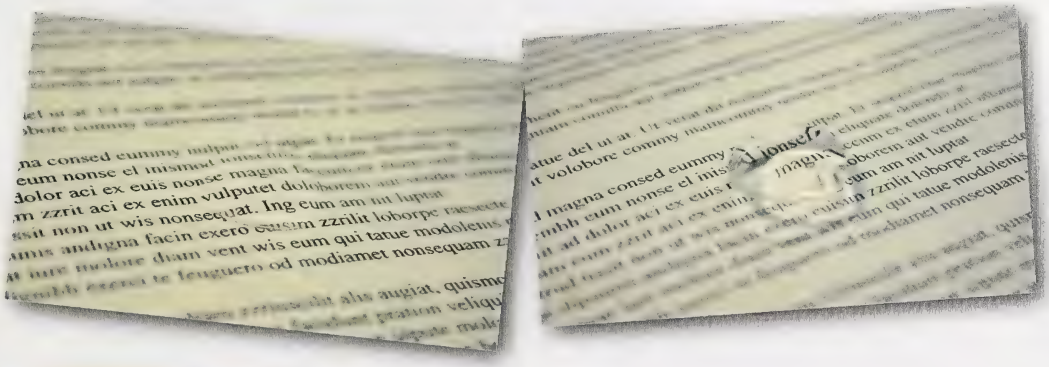
Activity 9B: Refraction

9. What do you notice about the letters seen through the water droplet?

The letters appear to be larger under the water droplet.

10. Move the plastic wrap closer to and farther from the paper. What happens to the size of the letters as you move the plastic wrap?

The letters get bigger when the wrap moves away from the paper. They get closer to the original size when the wrap nears the paper.



Key Words

glance: hit and move off at a slant

refraction: the bending of light as it passes through a transparent object

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Lesson 10: Objects That Reflect

Have you ever tried looking at a piece of paper to see your reflection?

Of course not! While paper may reflect a lot of light, its surface is too rough to form an image. Today, you will find out which types of objects reflect light well and which things do not.

What makes a good reflector? Would a transparent object be a good reflector? No. If all the light passes through it, there is no light to reflect. To be a good reflector, an object must be opaque. What its surface is like is important too. Some shapes and materials also make better reflectors than others.

Compare a metal pot and a clay pot.

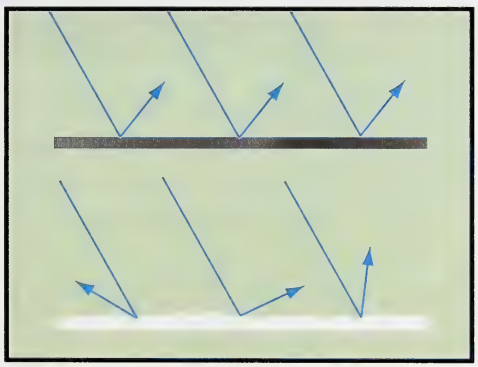
Which pot will show your reflected image the best? Did you guess the metal pot?

The metal pot gives a better reflection for these reasons:

- It is shiny.
- It has a very smooth surface.

What characteristics should an object have to be a good image reflector? You can use what you discovered from the metal and clay pots.

An object may reflect lots of light, but not give a clear image. A sheet of white paper is a good example of this. Its surface is quite rough compared to a mirror. The light bounces off the paper in all directions so an image doesn't form. If you have a magnifying glass, examine this page. Are you surprised?



Use a magnifying glass to see how rough many surfaces really are. Examine several things around your home.

To form an image (like you see in a mirror) the surface needs to be very smooth. Smooth surfaces let light reflect evenly.

Even though you may think of water as transparent, it can give a good reflected image. This has a lot to do with the angle that you are looking from. (Of course, the water needs a smooth surface too. Big frothy waves break up the reflection.)

A good reflector absorbs less light from the object than it reflects. If too much light is absorbed, there is not enough for you to see. The more light that is reflected, the more there is for you to see. (Recall that you see an object only when enough light from it reaches your eyes.)

You will look at these two characteristics of reflectors more closely in Activity 10.

Activity 10: Reflectors

In this activity, you will classify the objects around you as good or bad image reflectors.

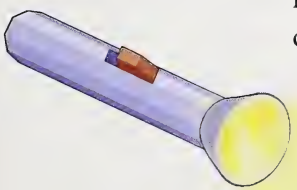
What you need

- a flat, smooth piece of aluminum foil
- a sheet of white paper
- a metal spoon
- a piece of wood
- a towel
- a quarter
- a plastic toy
- at least 4 other objects of your choice
- a flashlight
- a dark room

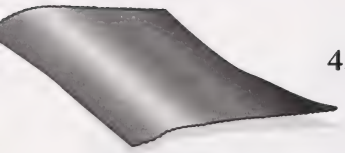
What to do

1. Take your objects and the flashlight into a dark room. Stand facing a wall.

2. Hold the aluminum foil in front of you, like you did with the mirror in Activity 9A: Reflection. (Make sure your aluminum foil is completely flat—it may help to tape it onto a piece of cardboard. The shiny side should be facing the wall.)

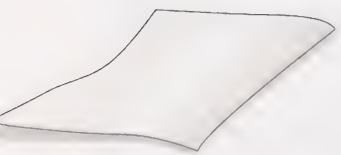


3. Shine the flashlight onto the piece of aluminum foil. Observe how the beam of light is reflected onto the wall.



4. If an object reflects light onto the wall like the aluminum foil does, it is a good image reflector. Record "smooth aluminum foil" in the Good Image Reflectors column of the following chart.

Good Image Reflectors	Bad Image Reflectors



5. Shine the flashlight onto the sheet of paper. Notice how the wall may get lighter, but there is no narrow beam of light reflected onto the wall. If an object does not reflect a strong beam of light, it is not a good image reflector. Record "paper" in the Bad Image Reflectors column of the chart.

6. Test all of the objects you have chosen. Decide if each is a good or bad image reflector. Record your information in the chart.

7. Crumple your piece of aluminum foil into a ball and then flatten it out again. Test it again using the flashlight. Is it still a good image reflector?

_____

8. What is the difference between reflecting light on the smooth aluminum foil and on the crumpled aluminum foil?

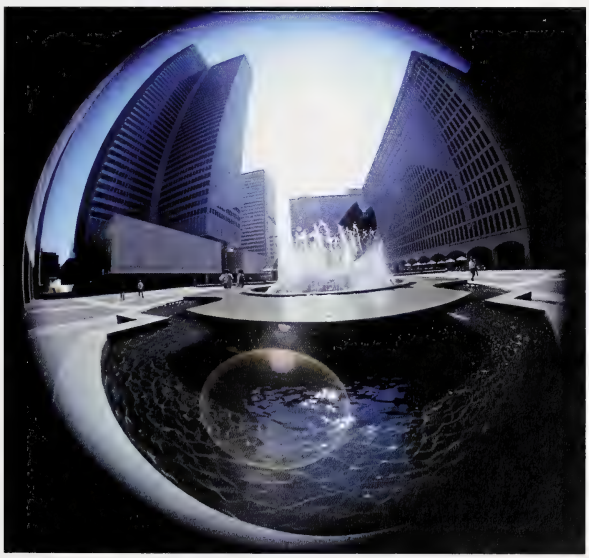
_____

_____

_____

Check your answers for this activity in the Suggested Answers at the end of this lesson.

Polished metal objects and mirrors are the best reflectors. They are opaque and smooth, and they don't absorb much light. Look closely at a mirror. Does it have a colour of its own? To be a good mirror, it must reflect the colours of the objects in front of it.



If metal and mirrors are the best reflectors, why don't we use them on bicycles for safety when riding at night? Take "A Closer Look" at bike reflectors!

Bicycle Reflectors

If you look at a bicycle reflector, you will notice that there are hundreds of small ridges at different angles. Why is this?

When you ride your bicycle at night, it is important that drivers can see you from every angle. If bicycle reflectors were flat mirrors, light would be reflected back only when a driver was straight out from the mirror (to the left or right of the bike). There would be no light reflected to the back of the bike.

The reflectors are made of hundreds or thousands of tiny cells. This is important because there is a limited amount of light at night. Each cell sends light back in the same direction it came from. This means that a driver can see the reflected light from many different angles. You can find out much more at the following website:

http://www.bikexprt.com/bicycle/reflectors/reflwrk.htm

Have you noticed that most bicycle reflectors are red or yellow? Why aren't they colourless like a mirror?

If a driver saw a colourless light ahead, he or she might not know that the light was reflected by a bicycle. A coloured reflector lets motorists know they are approaching a bicycle.

There are thousands of places where reflectors are used. In the next lesson, you will find out about some of the technologies that have been created using reflectors.

What about the reflective tape used on uniforms? Is it similar to a bike reflector? You can find out more on the following website:

http://www.cyberglow.co.uk/reflective.htm

Suggested Answers

Activity 10: Reflectors

6. Test all of the objects you have chosen. Decide if each is a good or bad image reflector. Record your information in the chart.

Good Image Reflectors	Bad Image Reflectors
smooth, flat aluminum foil	paper
metal spoon	piece of wood
quarter	towel
The plastic toy and four optional items may be good or bad reflectors, depending on what was chosen.	The plastic toy and four optional items may be good or bad reflectors, depending on what was chosen.

7. Crumple your piece of aluminum foil into a ball and then flatten it out again. Test it again using the flashlight. Is it still a good image reflector?

   No, the crumpled aluminum is no longer a good image reflector.

8. What is the difference between reflecting light on the smooth aluminum foil and on the crumpled aluminum foil?

   Light reflected evenly off the smooth aluminum foil. It made a beam of light on the wall. The crumpled foil no longer had a smooth surface. Light reflected off the crumpled foil in many directions. No single strong beam of light showed on the wall.

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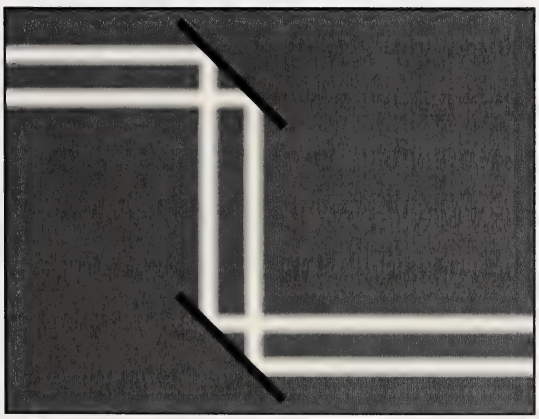
Lesson 11: Reflecting Technologies

Have you read the story about Snow White? In the fairy tale, Snow White's stepmother used a mirror to tell her who was the fairest one of all. Scientists haven't figured out how to use mirrors to do this yet, but they have used mirrors to let us see things in completely new ways. Today, you will look at some of these reflecting technologies.

Periscopes

A periscope lets you see things above you or around corners. Periscopes are used in submarines and tanks. In a submarine, a periscope is used to see above the water. It's a lot safer to use a periscope than for the submarine to come to the water surface.

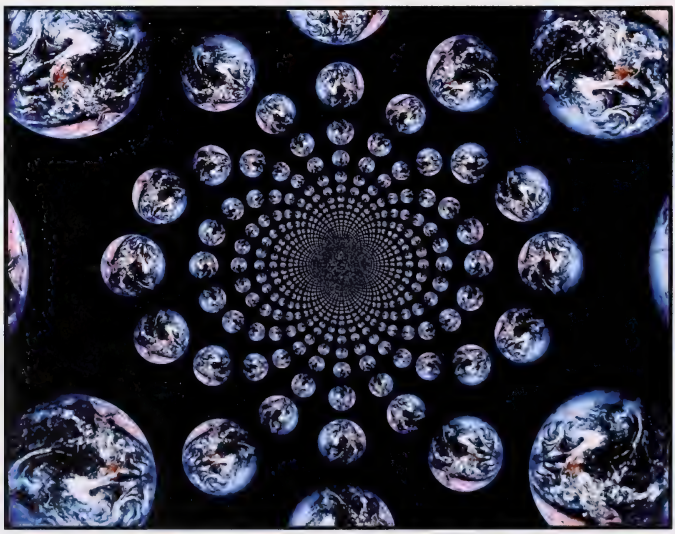
How could you make a periscope? You would put mirrors at each end of a long tube. You look through the bottom end, and the top end points in the direction you want to see. The longer the tube of the periscope, the smaller the image you see. When the tube is very long, you need a lens to make the image big enough to see clearly.



Kaleidoscopes

A kaleidoscope lets you see many images of an object at one time. Kaleidoscopes are used to make toys, or they are used in mirror funhouses.

Kaleidoscopes are made by forming angles with mirrors. The mirrors are placed so that one mirror reflects the image created by another mirror.



Today's activity lets you experiment with reflection by making your own kaleidoscope.

Activity 11: Making a Kaleidoscope

In this activity, you will make a small kaleidoscope. If you would like to make a larger kaleidoscope, you can go to the Optional Follow-up Activities at the end of this section (Activity 3: King-Sized Kaleidoscope).

Be careful when handling the mirrors; the edges can be very sharp.

What you need

- a ruler
- a crayon or marble
- tape (Duct tape works best.)
- 3 small, flat, unframed mirrors (8 cm × 10 cm or so)

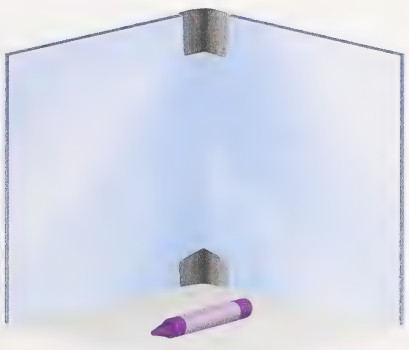
What to do

Ask your home instructor for help with this activity.

1. Tape two of the mirrors together along one edge to make a hinge. Leave a gap between the 2 mirrors so that you can bend them toward and away from each other.

2. Stand the mirrors up so they form a V-shape, with the outer corners far apart.

   Place the crayon (or marble) in the centre of the V-shape.



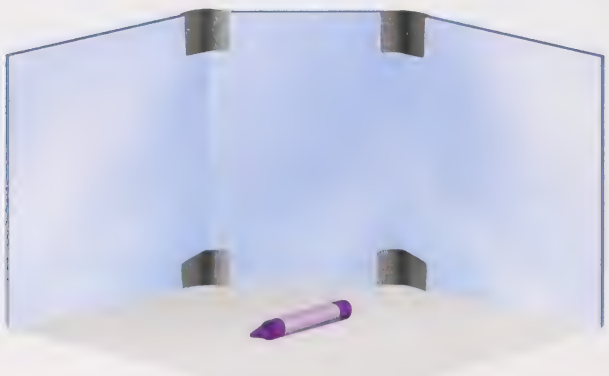
3. Put your face about 20 cm from the crayon (or marble). Without moving your head, how many reflections of the object can you see in the two mirrors? Record this number in the following chart.

Number of Mirrors	Number of Objects Seen When Corners Are Far Apart	Number of Objects Seen When Corners Are Closer Together	Number of Objects Seen When Corners Are Very Close Together
2			
3			

4. Move the outer corners toward each other. Put your face the same distance away from the crayon (or marble). How many reflections of the object can you see in the two mirrors? Record this number in the chart.

5. Move the outer corners toward each other so that they are quite close together, but you can still see between them. Put your face the same distance away from the crayon (or marble). How many reflections of the object can you see in the two mirrors? Record this number in the chart.

6. Tape a third mirror to the side of one of the hinged mirrors. The mirrors should now look like this. Place the crayon (or marble) in front of the middle mirror.



7. Repeat the same steps that you did with two mirrors. Start with the outer edges far apart, then move the outside edges closer together, and then closer together still. Each time, look at how many crayon (or marble) images you can see. Record these numbers in the chart (in Step 3).

8. As the edges of the mirrors get closer together, what happens to the number of images you can see?

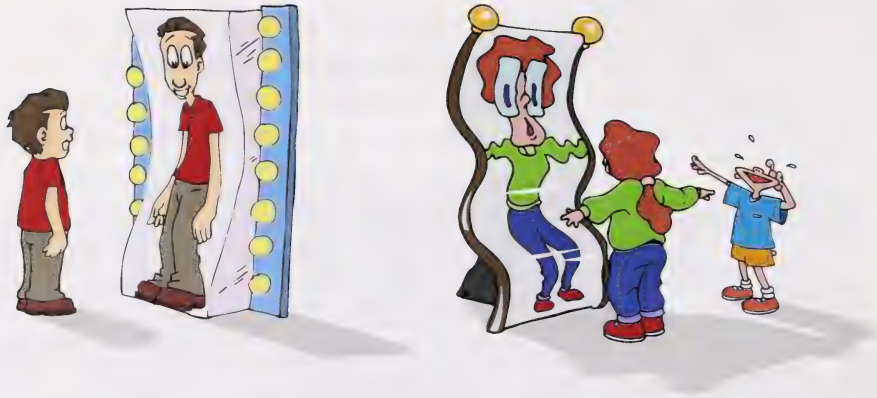
9. When you add another mirror, what happens to the number of images you can see?

10. Place the three mirrors so that the outer corners touch. Place the crayon (or marble) in the middle of this triangle of mirrors. Look at the images from the top. How many images of the object can you see?

Check your answers for this activity in the Suggested Answers at the end of this lesson.

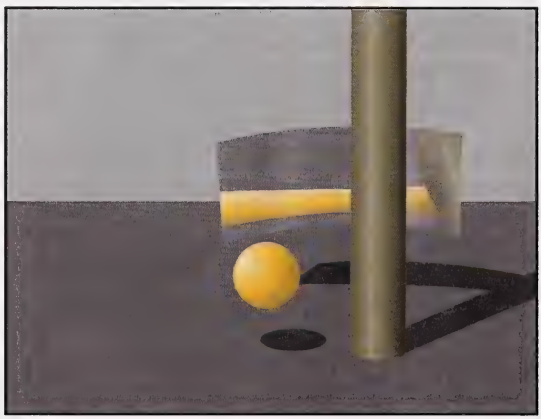
Curved Mirrors

Have you ever wondered why objects are closer than they appear when you look at them in the side mirror of a car? These mirrors are curved like the outside of a spoon. What happens if you look at the inside of a spoon? If you hold the spoon very close, you will notice that your image is big. As you move the spoon away from your face, your image flips upside down and gets smaller.

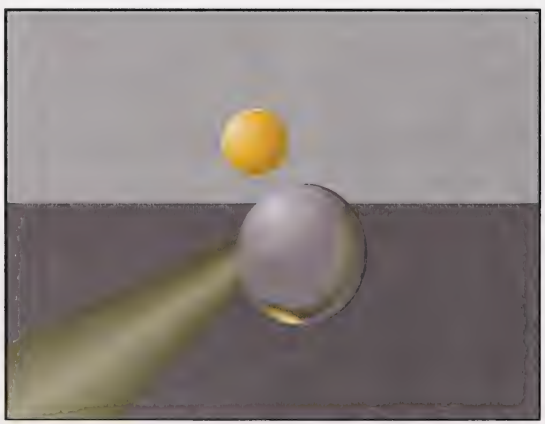


Curved mirrors are used to reflect a wider area than a flat mirror. You can see curved mirrors in side mirrors on a car, security mirrors in a store, and mirrors in fun houses.

What do you see in these illustrations?



At the front, you see a shiny orange ball and a wooden pillar. Behind them is a curved mirror. You see the reflection of the ball and the pillar in the mirror. The reflections are quite different from the objects themselves.



This illustration also shows a shiny orange ball and a wooden pillar. Instead of a mirror, there is a lens. You can see the image of the ball and part of the pillar through the lens. Again, the images are different from the objects.

The shape of the mirror used in the telescopes you will read about next is the same shape as the inside of a spoon.

Telescopes

Telescopes help us see objects that are very, very far away. When telescopes were first invented, they had no mirrors. They were simply tubes with lenses in them. Then scientists discovered that a curved mirror could be used to reflect the light from far-off stars. The bigger the mirror, the brighter the light that can be seen through a telescope. Telescopes with larger mirrors can see farther into the universe. They make **astronomy** very exciting.

astronomy: the study of planets, stars, and other objects in space

The largest telescope today is the Southern African Large Telescope. It has a mirror that is 11 m across. This large mirror gathers light from galaxies that are very far away.

How well does it gather light? It collects light so well that it could "see" a single candle burning on the Moon. (Well, it could see it if a candle could burn there!)

Imagine

There are plans to build even bigger telescopes in the future. The Overwhelmingly Large (OWL) Telescope in Germany will have a mirror with a diameter of 100 m. Scientists hope it will be working by 2018.

Telescopes are used to see distant stars, galaxies, and other objects in the sky. **Astronomers** chart the sky to identify what each object is and to give it a name.

astronomer: one who studies planets, stars, and other objects in space

Imagine

Have you noticed that many of the devices that use lenses and mirrors end in "-scope"? "-Scope" comes from the Greek word *skopeein*, which means "to look."

Hundreds of things around you reflect light. Scientists have invented many technologies that use mirrors. These technologies help people see more of the world and the universe.

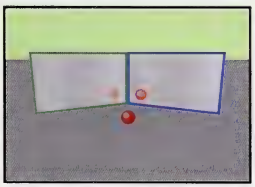
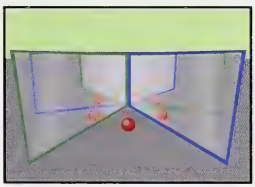
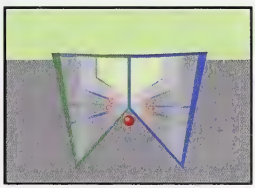
Turn to Assignment Booklet 3B and complete question 11 of the Section 3 Assignment.

Suggested Answers

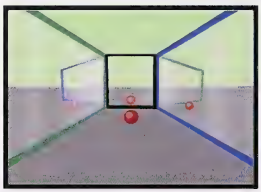
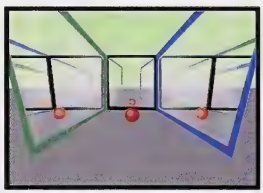
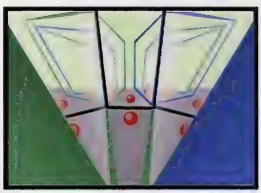
Activity 11: Making a Kaleidoscope

3.–5. Put your face about 20 cm from the crayon (or marble). Without moving your head, how many reflections of the object can you see in the two mirrors? Record this number in the following chart.

For Steps 4 and 5, you moved the mirrors closer together.

Number of Mirrors	Number of Objects Seen When Corners Are Far Apart	Number of Objects Seen When Corners Are Closer Together	Number of Objects Seen When Corners Are Very Close Together
2	Numbers will vary. For example, you may see 3 objects. 	Numbers will vary but will be higher than the number when the corners were far apart. For example, you may see 7 objects. 	Numbers will vary but will be higher than the other trials with 2 mirrors. For example, you may see 9 objects. 

7. Repeat the same steps that you did with two mirrors. Start with the outer edges far apart, then move the outside edges closer together, and then closer together still. Each time, look at how many crayon (or marble) images you can see. Record these numbers in the chart.

Number of Mirrors	Number of Objects Seen When Corners Are Far Apart	Number of Objects Seen When Corners Are Closer Together	Number of Objects Seen When Corners Are Very Close Together
3	Numbers will vary but will be higher than the number with 2 mirrors. For example, you may see 4 objects. 	Numbers will vary but will be higher than both the trial with 2 mirrors and the trial with 3 mirrors and the corners far apart. For example, you may see 8 objects. 	Numbers will vary but will be the highest number out of all of the trials. For example, you may see 10 objects. 

8. As the edges of the mirrors get closer together, what happens to the number of images you can see?

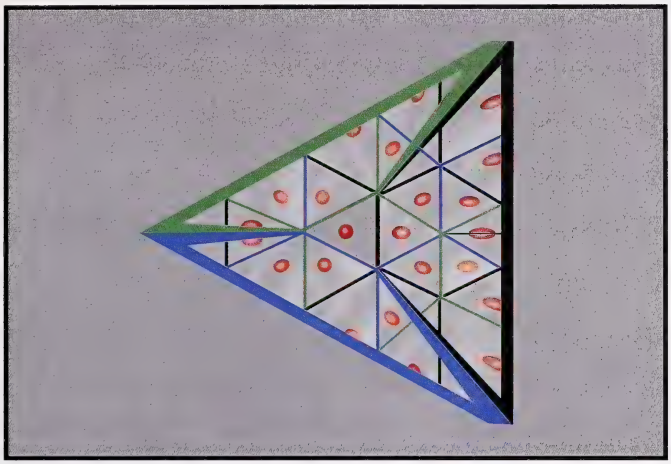
You should have seen more images of the crayon or marble when the edges got closer together.

9. When you added another mirror, what happened to the number of images you could see?

You should have seen more images of the crayon or marble when another mirror was added.

10. Place the three mirrors so that the outer corners touch. Place the crayon (or marble) in the middle of the triangle that was created. How many images of the object can you see?

There were a lot of images of the crayon when the mirrors formed a triangle. The sample shows more than 20 images of the object.



Key Words

astronomer: one who studies planets, stars, and other objects in space

astronomy: the study of planets, stars, and other objects in space

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Lesson 12: Bending Light

Have you ever dived into a lake or pool? Did you notice that the water slowed you down and changed your direction?

When light enters water, it slows down, too. When light slows down, it bends and changes direction, just like you did. Today, you will explore more about what substances bend light, and how they do it.

Light generally travels in a straight line through the air. When light hits a transparent object, it may slow down. As light slows down, it bends.

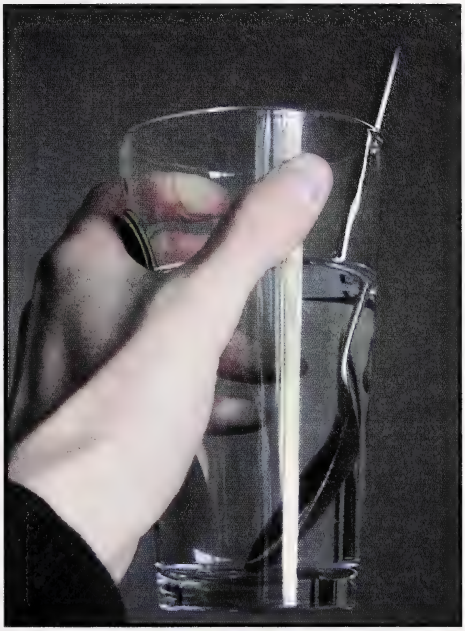
Imagine

Objects in the distance sometimes appear wavy on a hot day. This is because rising hot air and moisture in the air bend the light as it travels toward you.

How light bends depends on

- what the transparent object is made of
- the shape of the object

Try this little experiment with a clear, tall drinking glass, water, and a spoon. Fill the glass with water. Set the spoon into the glass. How does the spoon look through the side of the glass? The spoon should look slightly crooked at the point where the spoon enters the top of the glass. The spoon should look VERY crooked as you look at the point where it enters the water. This shows that the water is bending the light more than the glass bends the light.



Activity 12: Changing the Direction of Light

You can change the direction that light travels by having it move through a transparent material. In this activity, you will compare how much light bends as it travels through different substances.

Ask your home instructor for help with this activity.

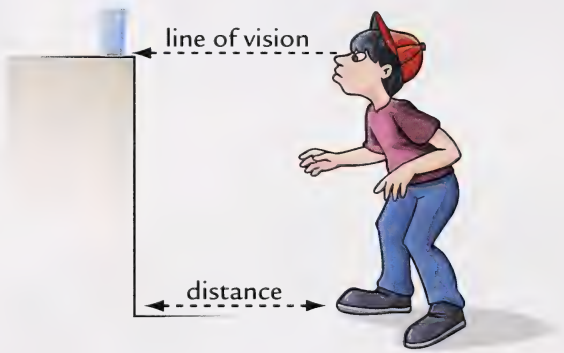
What you need

- a clear drinking glass
- a penny
- water
- about 50 mL vinegar
- about 50 mL cooking oil
- a helper
- a measuring tape or metre-stick

What to do

1. Put the penny into the empty glass. Place the glass on a counter. Stand away from the glass so that you can just see the edge of the coin.

2. Ask your helper to measure the distance from your feet to the bottom of the counter.



Distance from empty glass: _____ cm

3. Stay where you are and ask your helper to slowly pour water into the glass. What do you observe?

_____

4. Move so that you can just see the edge of the coin again. Measure the distance from your feet to the bottom of the counter.

   Distance from water-filled glass: _____ cm

5. Stay where you are and ask your helper to empty the water out of the glass. (Keep the penny in the glass.) Ask your helper to put the glass back in the same spot and to pour about 50 mL vinegar into the glass. What do you observe?

   _____

   _____

6. Move so that you can just see the edge of the coin again. Measure the distance from your feet to the bottom of the counter.

   Distance from vinegar-filled glass: _____ cm

7. Stay where you are and ask your helper to empty the vinegar out of the glass. (Keep the penny!) Ask your helper to put the glass back in the same spot and to pour about 50 mL cooking oil into the glass. What do you observe?

   _____

8. Move so that you can just see the edge of the coin again. Measure the distance from your feet to the bottom of the counter.

   Distance from oil-filled glass: _____ cm

9. Some liquids can bend light more than others. For those liquids that bend light a lot, you must stand closer to the counter to see the object in the glass. For those liquids that bend light less, you can stand farther from the counter and be able to see the object in the glass.

10. Write number 1 beside the liquid you had to stand closest to. Write number 3 beside the liquid you were able to stand farthest from. Number 2 will go with the liquid in the middle.

_____ water _____ vinegar _____ oil

11. Which liquid bent the light the most? How do you know?

_____

_____

_____

_____

_____

Check your answers for this activity in the Suggested Answers at the end of this lesson.

Try this simple experiment.

Check with your home instructor before doing this activity.

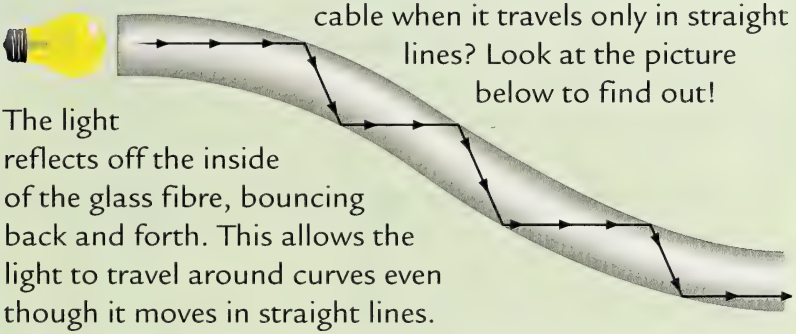
Is there any cut glass or crystal in your home? If there is, you can try this activity. You will need a cut glass or crystal drinking glass and a plain drinking glass. You will also need two small objects that are the same. Small, unbreakable toys or figurines would work great! Gently put an object in each of the glasses. Which container lets you see the object most clearly? The plain glass does not bend the light as much as the cut glass container does. Because of this, it is easier to see the object in the plain container.

Some substances bend light more than others. The shape of an object may also affect how much the light bends.

Fibre Optics

You may have heard about fibre optics when people were talking about telephones, cable, or the Internet. Fibre optics are made of pure glass strands as thin as human hair.

These tiny strands are put into a bundle called a cable. Light can travel along these cables for very long distances. How can light follow the twists and turns of a fibre-optic cable when it travels only in straight lines? Look at the picture below to find out!



The light reflects off the inside of the glass fibre, bouncing back and forth. This allows the light to travel around curves even though it moves in straight lines. Fibre-optic cables run around corners, through walls, and underground. The light follows this path.

In the next lesson, you will discover more about how the shape of an object affects how it bends the direction of the light travelling through it.

Turn to Assignment Booklet 3B and complete question 12 of the Section 3 Assignment.

Suggested Answers

Activity 12: Changing the Direction of Light

2. Ask your helper to measure the distance from your feet to the bottom of the counter.

Distance from empty glass: Answers will vary.

3. Stay where you are and ask your helper to slowly pour water into the glass. What do you observe?

The penny seems to disappear.

4. Move so that you can just see the edge of the coin again. Measure the distance from your feet to the bottom of the counter.

Distance from water-filled glass: Answers will vary, but this distance will be less than the distance you measured for the empty glass.

5. Stay where you are and ask your helper to empty the water out of the glass. (Keep the penny in the glass.) Ask your helper to put the glass back in the same spot and to pour about 50 mL vinegar into the glass. What do you observe?

The penny may seem to disappear. Whether it disappears completely will depend on the angle from which you are looking.

6. Move so that you can just see the edge of the coin again. Measure the distance from your feet to the bottom of the counter.

Distance from vinegar-filled glass: Answers will vary, but this distance should be slightly less than the distance you measured for the water-filled glass.

7. Stay where you are and ask your helper to empty the vinegar out of the glass. (Keep the penny!) Ask your helper to put the glass back in the same spot and to pour about 50 mL cooking oil into the glass. What do you observe?

Again, the penny will seem to disappear.

8. Move so that you can just see the edge of the coin again. Measure the distance from your feet to the bottom of the counter.

Distance from oil-filled glass: Answers will vary, but this distance should be less than the distances you measured for either the water-filled or vinegar-filled glasses.

10. Write number 1 beside the liquid you had to stand closest to. Write number 3 beside the liquid you were able to stand farthest from. Number 2 will go with the liquid in the middle.

3 water 2 vinegar 1 oil

11. Which liquid bent the light the most? How do you know?

The cooking oil bent the light the most. The light slowed down the most in oil, causing the light rays to bend more. You know this because you had to stand closest to the counter in order to see the penny. The more the light was bent, the closer you had to stand to see the penny.

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Lesson 13: Lenses

Do you wear eyeglasses? If you do, you can be thankful that scientists discovered how to bend light to help your eyes see. In this lesson, you will explore lenses. You will see how they work and find out where you can find them.

Lenses are usually made of glass or plastic. They are shaped so that they will bend light. Lenses can be two basic shapes: concave and convex.

Concave Lens

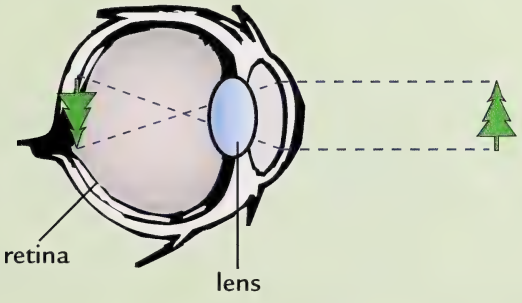
concave lens: a piece of glass or plastic that is thicker around the edges than in the middle

The following diagram shows a concave lens.

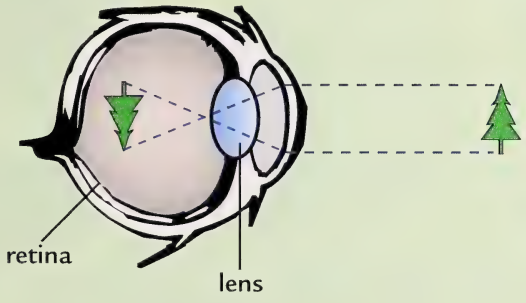
A concave lens is thickest around its edges. Its middle is the thinnest part. These lenses make an object appear smaller and farther away.

Nearsightedness

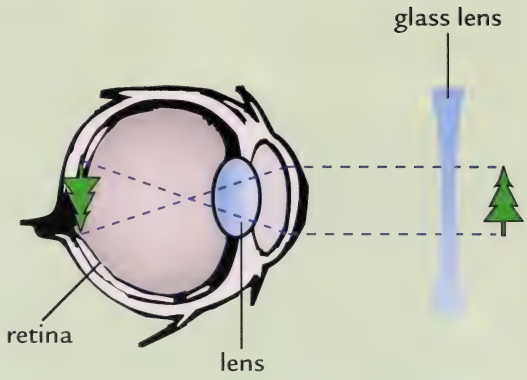
Normally, the lens at the front of the eye focuses an image on the retina or back of the eye. (The diagrams show a simplified drawing of an eye.)



The lens of a nearsighted person focuses the image in the middle of the eye. This makes the image seem blurry. The best images form when objects are close to the eyes. A far-away object like a tree in the distance will be blurry. This is why the condition is called nearsightedness or shortsightedness.



The right choice of a lens can help a nearsighted person see better. The lens must change the way light reaches the eye. It has to make up for the poor focus of the eye's lens.



A concave lens will change the way light reaches the eye. It will help the eye focus the image on the retina.

If you are nearsighted, take off your glasses and hold them about 30 cm from your face. As you look through the lens, what do objects look like? They should look smaller and farther away than they actually are.

Convex Lens

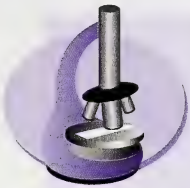
convex lens: a piece of glass or plastic that is thinner at its edges and thicker in the middle

The following diagram shows a **convex lens**.

A convex lens is thicker in the middle than at the edges. A convex lens helps to focus an image. It makes light rays converge or come together. A convex lens can also make an object appear larger than it actually is. Examples of objects that use convex lenses are cameras, telescopes, a magnifying glass, and microscopes.

Think back to your activity with the water droplet on plastic in Activity 9B: Refraction. The water droplet was thicker in the centre than at the edges. That makes it a convex lens!

Microscopes



A Great Scientist

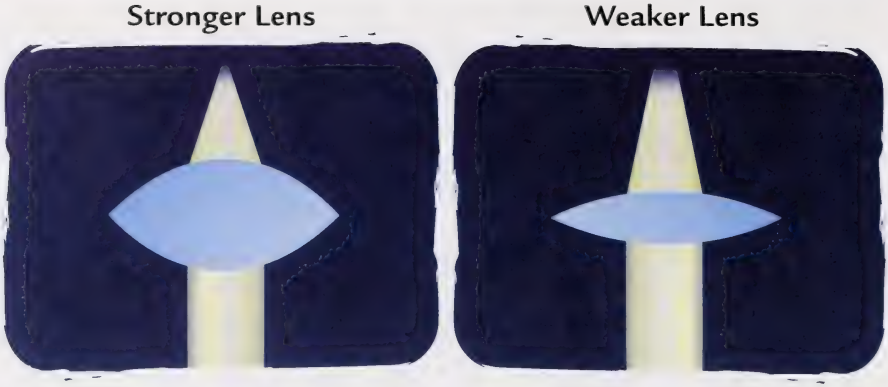
Anton van Leeuwenhoek

The first microscope was invented in the 1600s by Anton van Leeuwenhoek.

Van Leeuwenhoek was a master lens maker in Holland. Van Leeuwenhoek placed convex lenses to create simple microscopes. He used his microscopes to discover and describe bacteria, small insects, and the cells of living things.

The lenses in a microscope are convex lenses. Modern compound microscopes have many lenses. Often you look into two lenses. These are the eyepieces. Another lens is placed very close to the item being looked at.

The lens close to the subject can be changed. You would use a strong lens when you need to see very small details. Strong lenses bend the light a lot. You would use a weaker lens when the details are larger.



Microscopes allow you to see very small objects, such as bacteria and plant and animal cells.

This is a sugar crystal seen through a microscope.

Microscopes help you in many ways:

- Doctors can see if you have certain diseases.
- Researchers can find cures for disease.
- Scientists can learn more about how plants work.
- Biologists can find out if a pond is healthy by looking at the small living things in it.

Activity 13: Lens Maker

You are going to
make your own lens
and view an object through it.
The results may surprise you!

What you need

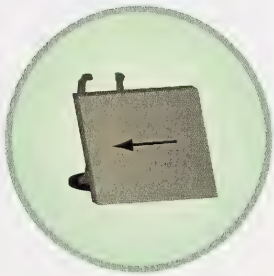
- water
- a ruler
- a clear, round, straight-sided drinking glass
- a piece of cardboard (about 6 cm × 6 cm)
- an object you can use to prop the cardboard
- a thick marker (felt pen)

What to do

1. Use the marker to draw an arrow on the cardboard. The arrow should be about 3 cm long.

2. Fill the drinking glass with water.

3. Prop the cardboard on a table, with the arrow pointing to your left. (In the diagram, a small toy is used to prop the cardboard.)



4. Place the drinking glass so that it touches the arrow on the piece of cardboard.

5. Bend down so that you are looking at the arrow through the glass of water.

6. In which direction is the arrow pointing?

_____

7. While looking through the glass of water, slowly pull the glass away from the piece of cardboard. What happens to how you see the arrow?

_____

8. Slide the glass toward the cardboard and away from the cardboard once again.

9. What happens to the arrow as you move the glass toward the cardboard?

_____

10. What happens to the arrow as you move the glass away from the cardboard?

_____

11. Look carefully at the drinking glass. What type of lens is it? Explain.

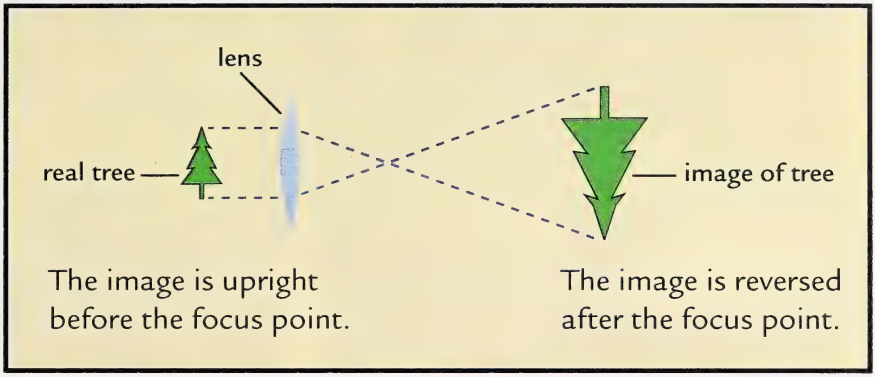
_____

_____

Check your answers for this activity in the Suggested Answers at the end of this lesson.

Did you expect the arrow to be turned around? Why?

When the light was bent by the lens (the glass of water), light rays crossed at a point between your eyes and the lens. When the rays reached your eyes, a reversed (turned around) image was created. That's why the arrow appeared to be reversed. You can see how this works in the following diagram.



There are people who work with lenses all the time. One example is the people who make lenses for eyeglasses. These people are called opticians. Maybe there is one in your community. Opticians must shape each lens so that it corrects a person's eyesight. An optician must also cut the lens so that it fits into the frames that have been chosen. If you wear eyeglasses, an optician made the lenses that you are wearing right now!

The shape of a lens affects how light bends. The material in a lens will also make a difference. Bending is only one way that the direction of light can be changed.

Turn to Assignment Booklet 3B and complete question 13 of the Section 3 Assignment.

Suggested Answers

Activity 13: Lens Maker

6. In which direction is the arrow pointing?

The arrow is pointing left.

7. While looking through the glass of water, slowly pull the glass away from the piece of cardboard. What happens to how you see the arrow?

At a point a few centimetres away from the cardboard, you will see that the arrow is now pointing to the right.

9. What happens to the arrow as you move the glass toward the cardboard?

As you move the glass toward the cardboard, the arrow will point to the left again.

10. What happens to the arrow as you move the glass away from the cardboard?

The arrow points toward the right as you move the glass away from the cardboard.

11. Look carefully at the drinking glass. What type of lens is it? Explain.

The drinking glass full of water is a convex lens. This is because the outer edges are thinner than the centre.

Key Words

concave lens: a piece of glass or plastic that is thicker around the edges than in the middle

convex lens: a piece of glass or plastic that is thinner at its edges and thicker in the middle

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Lesson 14: White Light

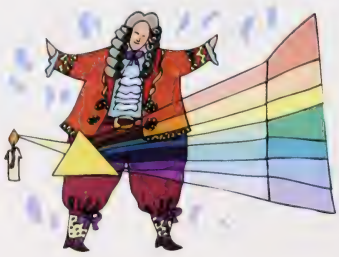
White light is made of all the colours of light. White light lets you see all of the colours around you. Today, you will split white light into its parts.

Have you ever seen a rainbow? Rainbows show you that white light can be split into many different colours. What are they?

A rainbow shows a full range of colours. These colours include red, orange, yellow, green, blue, indigo, and violet. Red is the outer colour of the rainbow, and violet is the inside colour.

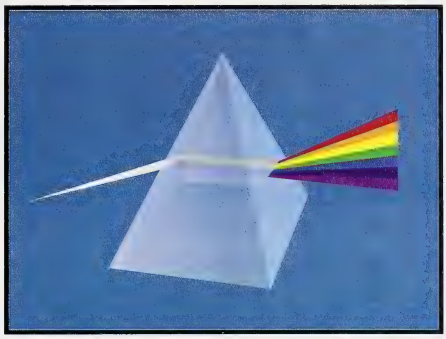
STUDY HINT: Do you think you might need help remembering the order of these colours? Try using the first letters of the colours to make the name "ROY G. BIV."

Scientists discovered that they could use a special shape of glass, called a prism, to separate white light into colours.



spectrum: the band of colours made by splitting up white light

This beautiful display of coloured light is called a **spectrum**.



You can play with light and a prism on the following website.

http://webphysics.ph.msstate.edu/javamirror/explrsci/dswmedia/prism.htm

How does a rainbow form? Take "A Closer Look" to find out!

Rainbow Science

Sunlight is an example of white light. A rainbow is made when sunlight shines through water droplets. Water droplets make the white light split up into a band of different colours. This band of colours is called a spectrum.

Sometimes you can see a second, paler rainbow above the bright rainbow. The colours in this rainbow are reversed, with red as the inside colour of the rainbow and violet as the outer colour.

You can see a rainbow only if the Sun is behind you.

Activity 14: Bubble Rainbows

Using soap is a fun way to make your own rainbow or spectrum. Do this activity outside on a sunny day so there will be plenty of light and no mess to clean up!

What you need

- 40 mL liquid dish detergent (Dawn™ works best.)
- 5 mL glycerine* (optional)
- 1 L water
- measuring spoons
- a measuring cup
- a spoon for mixing
- a metal coat hanger
- yarn (optional)
- a tray large enough to hold your bubblemaker

* available at pharmacies, toiletries departments

What to do

1. Make a bubblemaker. Carefully pull and bend a coat hanger into a circle shape. Bend the hook up so you can hold onto it.

2. To make better bubbles, wrap the circle part of your bubblemaker with yarn. The yarn will soak up the bubble solution.

3. Make your bubble solution. Mix the soap, glycerine, and water in the tray.

4. If you have time, let the bubble solution sit overnight. This lets the small bubbles disappear and you will get better big bubbles.

5. Go outdoors if you can. Dip your bubblemaker into the solution so it is completely covered.

6. Slowly raise the bubblemaker so that it is straight up and down. You may need to move your bubblemaker so it catches the light. What colours do you see in the bubble solution? List them in the order you see them.

_____

_____

7. Wave your bubblemaker to make bubbles. Have fun!

   You may want to share the fun with other family members.

Check your answers for this activity in the Suggested Answers at the end of this lesson.

primary colours of light: red, green, and blue

When you try to make white light, you can use all colours of light or just the primary colours of light. The primary colours of light are red, green, and blue.

In the next lesson, you will find out more about the primary colours of light and how they mix to make different colours of light.

Turn to Assignment Booklet 3B and complete question 14 of the Section 3 Assignment.

Suggested Answers

Activity 14: Bubble Rainbows

6. Slowly raise the bubblemaker so that it is straight up and down. You may need to move your bubblemaker so it catches the light. What colours do you see in the bubble solution? List them in the order you see them.

The colours red, blue, green, and yellow should have been seen. This order lists them from the top down. You may also have been able to see a band of violet between the red and blue colours.

Key Words

primary colours of light: red, green, and blue

spectrum: the band of colours made by splitting up white light

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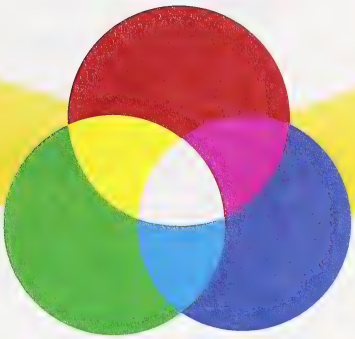
photo: Eyewire Collection/Getty Images

Lesson 15: Making Colours



If white light can be broken into the primary colours of light—red, green, and blue—what happens if you put these colours together again?

Will putting red, green, and blue together make white light? What will happen when red and blue light are put together? Get mixing to find out!

When you first learn to paint or colour, you discover that colours can be mixed to make other colours. However, mixing paint and mixing light are different.

Mixing Colours of Paint

You can play with mixing different **colours of paint** at the following websites:

- http://webphysics.ph.msstate.edu/javamirror/explrsci/dswmedia/colorsub.htm
- http://www.ontariosciencecentre.ca/scizone/games/subtracting/default.asp

Mixing Colours of Light

Play with adding different **colours of light** together by visiting the following websites:

- http://webphysics.ph.msstate.edu/javamirror/explrsci/dswmedia/coloradd.htm
- http://www.ontariosciencecentre.ca/scizone/games/adding/default.asp

Activity 15: Colour Mixing

In this activity, you will compare mixing colours of paint with mixing colours of light.

What you need

- 4 flashlights
- scissors
- tape
- a room that can be darkened
- 2 sheets of white paper
- a paintbrush or eyedropper
- red, green, yellow, and blue paint*
- red, green, yellow, and blue cellophane**

* tempera paints, water colours, finger paints, or vegetable food colouring

** Coloured tissue paper brushed with cooking oil and allowed to dry will also work.

What to do

1. Predict what colours will be made when you mix the colours of **paint** listed. Write your predictions in the middle column of the following chart.

Paint Colours Mixed	Predicted Colour of Paint	Colour Made When Paints Are Mixed
red + green		
red + blue		
red + yellow		
blue + green		
blue + yellow		
green + yellow		
red + green + blue		

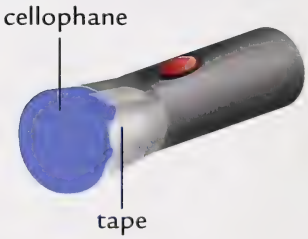
2. Now mix red and green paint on a piece of white paper. Record the colour you made in the third column of the chart. Repeat this step for the other colour mixes, one set at a time.

   Thoroughly rinse your paintbrush or eyedropper between each set of colours.

3. Predict what colours will be made when you mix the colours of **light** listed. Write your predictions in the middle column of the following chart.

Light Colours Mixed	Predicted Light Colours	Colour Made When Light Colours Are Mixed
red + green		
red + blue		
red + yellow		
blue + green		
blue + yellow		
green + yellow		
red + green + blue		

4. Cut a piece of each colour of cellophane (or the dried, oiled tissue paper). Make each piece big enough to fit over the flashlight. Tape each piece of cellophane onto a different flashlight.



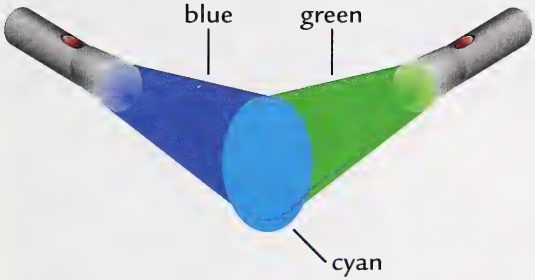
5. Tape a piece of white paper to the wall or the door in a room that can be made dark.

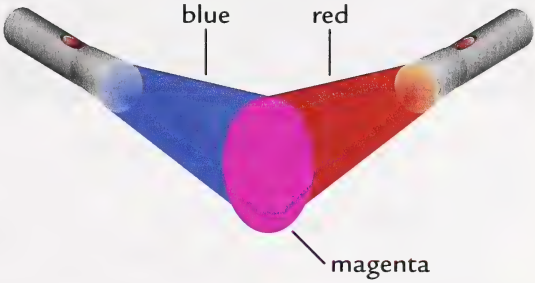
6. Shine the red and green flashlights onto the same spot on the white paper in the dark room. Record the colour you made in the chart (in Step 3). Repeat this step for the other coloured light mixes, one set at a time. (**Note:** You may need some help holding the 3 flashlights.)

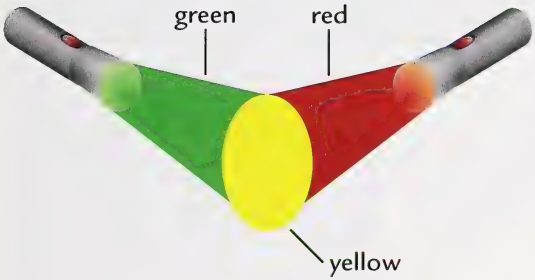
Note: Save your covered flashlights if you want to do Activity 4: What Colour? in the Section 3: Optional Follow-up Activities.

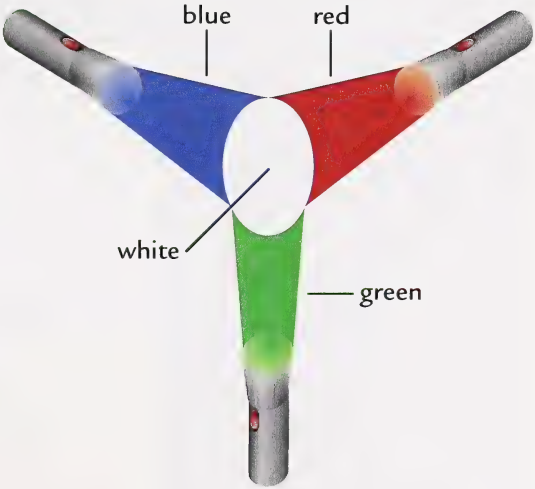
Check your answers for this activity in the Suggested Answers at the end of this lesson.

Were you surprised at the colours you got when you mixed different colours of light? Here is a quick review of how the primary colours of light mix together.









As you found out, mixing light is very different from mixing paint! Who would have thought that you could make yellow light by mixing red and green light! Were you surprised that you didn't need all of the colours of the rainbow to get white? This is because your eyes have only three kinds of cells that respond to colour.

Turn to Assignment Booklet 3B and complete question 15 of the Section 3 Assignment.

Suggested Answers

Activity 15: Colour Mixing

1. Predict what colours will be made when you mix the colours of **paint** listed. Write your predictions in the middle column of the following chart.

Paint Colours Mixed	Predicted Colour of Paint	Colour Made When Paints Are Mixed
red + green	Your predictions will vary.	brown
red + blue		purple
red + yellow		orange
blue + green		blue-green
blue + yellow		green
green + yellow		yellow-green
red + green + blue		black

2. Now mix red and green paint on a piece of white paper. Record the colour you made in the third column of the chart. Repeat this step for the other colour mixes, one set at a time. Thoroughly rinse your paintbrush or eyedropper between each set of colours.

Answers are shown in the chart in question 1. Be sure you wash your paintbrush or eyedropper thoroughly between mixing each colour combination.

3. Predict what colours will be made when you mix the colours of **light** listed. Write your predictions in the middle column of the following chart.

Light Colours Mixed	Predicted Light Colours	Colour Made When Light Colours Are Mixed
red + green	Your predictions will vary	yellow
red + blue		magenta (Magenta is a purplish red.)
red + yellow		yellow
blue + green		cyan (Cyan is a greenish blue.)
blue + yellow		white
green + yellow		yellow
red + green + blue		white

6. Shine the red and green flashlights onto the same spot on the white paper in the dark room. Record the colour you made in the chart (in Step 3). Repeat this step for the other coloured light mixes, one set at a time.

Answers are shown in the chart. Were you surprised at how many ways you could make white or yellow?

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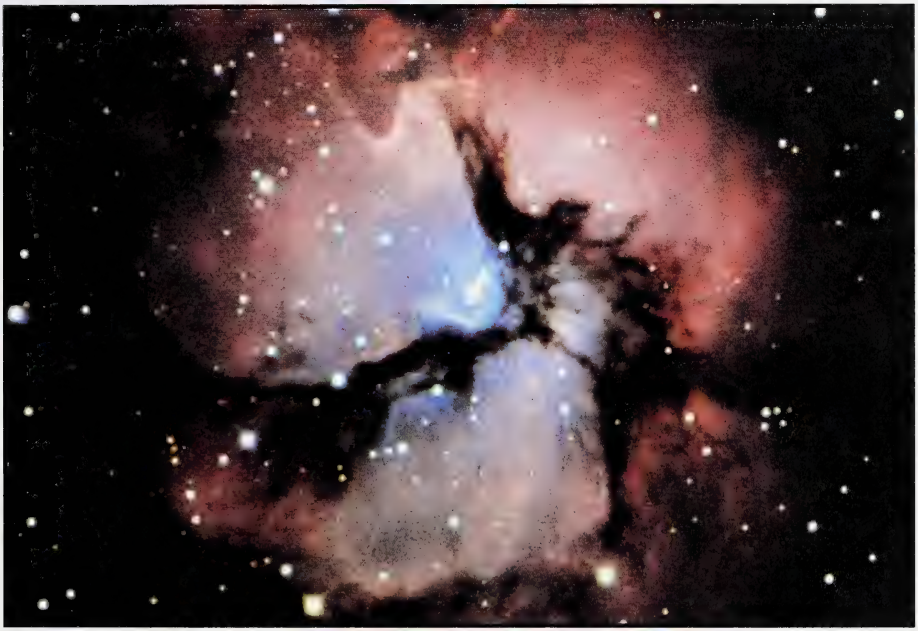
Section 3

Conclusion

You have discovered a lot about how light travels. Light will reflect or bend, depending on what type of object it hits. Many devices use the science of light to let you see the world around you in different ways.



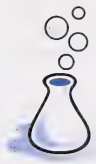
People usually think that white light has no colour. In fact, white light is made up of every colour of light! Thank goodness, or you wouldn't be able to see all of the wonderful colours around you every day.

Optional Follow-up Activities

Activity 1: Magnificent Magnifiers

In this activity, you will see how light moves through a magnifying glass.

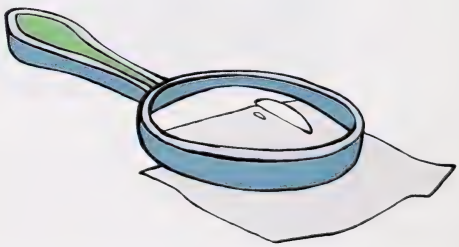
What you need



- a magnifying glass
- white paper
- a light source (the Sun or an incandescent lamp)

What to do

1. Shine your light source onto your magnifying glass. Place the paper behind the magnifying glass.



2. Move your magnifying glass to try to make the circle of light as small as possible.

Adult supervision is needed, especially if you are using the Sun as your light source. Do not hold the magnifying glass in front of the paper for long, because you could start a fire!

3. What is happening to the light rays as they move through the lens of a magnifying glass?

Activity 2: Up Periscope!

You can build a small periscope that will let you look over and around objects!

What you need

- 2 empty, rinsed 1-L paper milk cartons
- 2 small flat mirrors (about 8 cm x 10 cm)
- a utility knife or scissors
- a ruler
- a pen or pencil
- tape (preferably, duct tape)

Use special care when cutting. Have an adult supervisor.

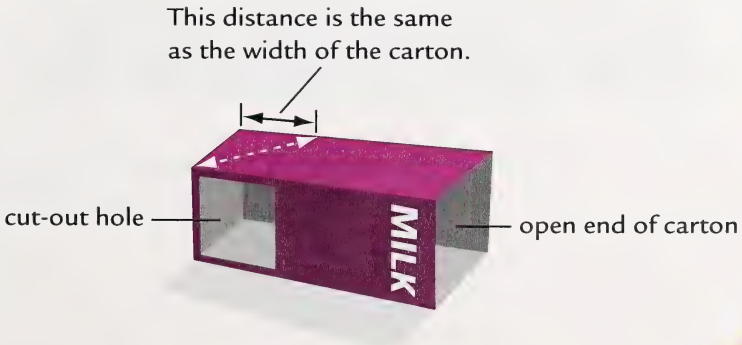
What to do

1. Cut off the peaked top from a milk carton.

2. Cut a square hole at the bottom of one side of the carton. Leave about 1 cm between the hole and the bottom and side edges of the carton.

3. Lay the carton on its side, with the hole facing sideways.

4. Measure the width of the milk carton. Measure this same distance up the side of the carton that is opposite the side that has been cut. Make a mark.

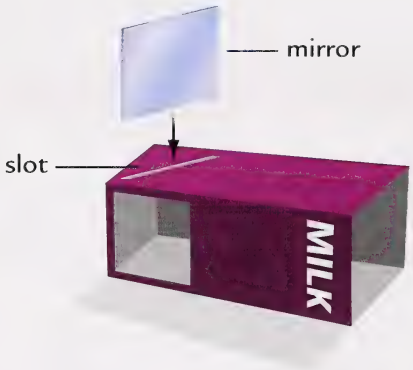


5. Draw a line from the corner under the hole you cut to the mark on the opposite corner (see the diagram in Step 4).

Ask your home instructor to help you with the next steps.

6. Make a slot along the line you drew. You will slide one mirror through this slot. If the mirror is narrower than the carton, attach the mirror to a piece of lightweight cardboard before sliding it in.

7. Slide the mirror into the slot and tape it in place. (Duct tape will stick to the waxed container.)



8. Stand the carton up with the hole facing you. You should be able to see the ceiling!

9. Repeat steps 1 to 7 for the other milk carton.

10. To put your periscope together, place the bottom carton with the open end up and the hole toward you. Hold the top carton with the open end down and the hole away from you.

11. Pinch the top carton together slightly so that it slides into the bottom carton. Tape the two cartons together.

12. Use your periscope to look at your world. It can help you see over fences, around walls, and under your bed!

Activity 3: King-Sized Kaleidoscope

In the activity in Lesson 11, you made a small kaleidoscope. In this activity, you will make a kaleidoscope that is big enough for you to see yourself!

Ask your home instructor for help with this activity.

What you need

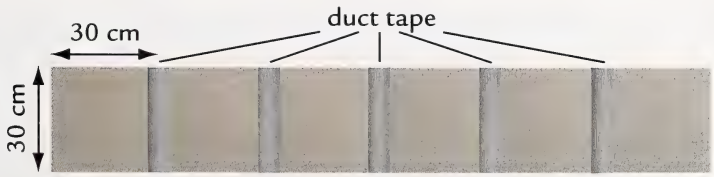
- 6 mirror tiles (30 cm × 30 cm)
- gloves (optional, for handling the tiles)
- duct tape
- a ruler
- a piece of strong cardboard (180 cm × 35 cm)
- scissors

The edges of the mirror tiles are sharp. Handle with care.

What to do

1. Place the six mirror tiles in a row so that their shiny sides face down.

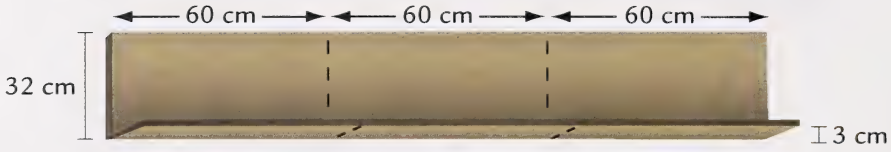
2. Use duct tape to tape the tiles together. Leave just enough room between the tiles so that the mirrors can bend at these taped joints.



3. Cover any sharp edges with duct tape.

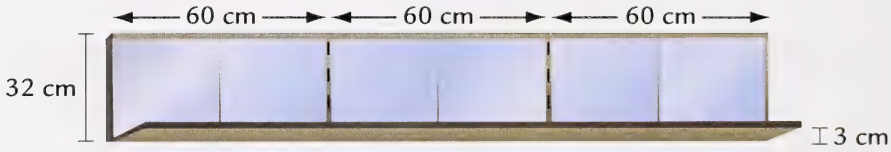
4. Mark the long edge of the cardboard every 60 cm. You can use the ruler and the scissors to score (lightly cut) lines across the width. This will make folding the cardboard easier.

   Make a 3-cm fold along one of the long edges of the cardboard. You may want to score the fold line before you make the fold. (**Note:** The diagrams are not drawn to scale.)



5. Fold the cardboard at the scored lines so that you form a triangle with three equal sides. (Each side will be 60 cm long.)

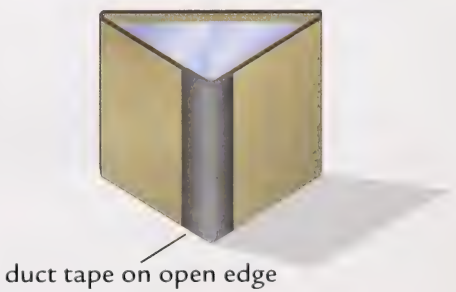
6. Lay the cardboard flat again. Place the row of mirrors (shiny side facing up) along the fold that you made on the long edge of the cardboard. Make sure that the creases you made in the cardboard every 60 cm match the duct-taped hinge (joint) between every pair of mirrors. Duct tape the mirrors along the fold.



7. Bend the cardboard's long edge over the mirrors to form a lip over the bottoms of the mirrors.

8. Fold the cardboard and mirrors to form a triangle with three equal sides.

   Securely duct tape the open corner.



9. Your kaleidoscope is now ready to use! You can see objects when you place them in the middle of your kaleidoscope, or you can put the whole kaleidoscope over your head! (This kaleidoscope is fairly heavy and fragile (breakable), so you may need help lifting and carrying it!)

Activity 4: What Colour?

The colours you see in your home are under white light. In this activity, you will look at objects in your home using coloured lights.

What you need

- the 4 "coloured" flashlights you made in Activity 15
- coloured objects from around your home
- a completely dark room

What to do

1. Under white light, look at each object you chose. Record its colour.

2. What colour do you think the object will appear to be using each of the coloured lights? Write down your predictions.

3. Take your object into a dark room and look at it with each of your coloured flashlights. Record your results.

4. Compare your predictions and your results.

5. Repeat steps 1 to 4 for each of your items.

Activity 5: Colour Wheel

You can mix colours using a simple colour wheel. The faster you spin the wheel, the better the colours will mix.

What you need

- a small spinning top or a sharpened pencil
- lightweight white cardboard
- red, blue, and green markers
- a round object to trace*
- a pencil
- tape
- a ruler
- a piece of black construction paper

* You could use a jar lid about 5 cm in diameter.

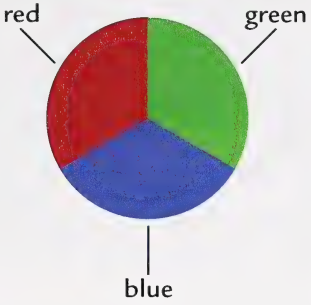
What to do

1. Trace and cut out four cardboard circles, each about 5 cm across.

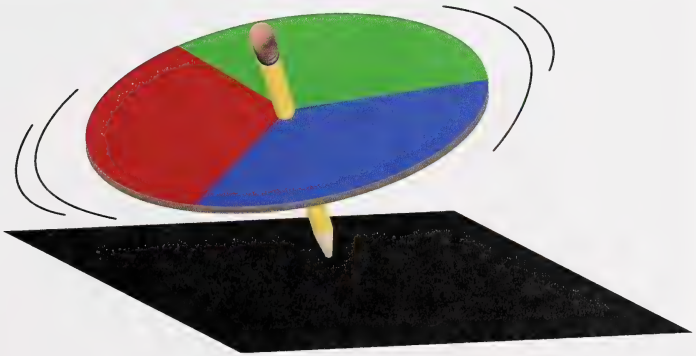
2. Draw a line down the middle of three of the circles.

   - Colour one circle green and red.
   - Colour one circle blue and red.
   - Colour one circle green and blue.

3. Divide the fourth circle into three equal pie-shaped parts. (Ask an adult to help you do this.) Colour one section red, one section green, and the last one blue.



4. Fasten one of the cardboard circles to the spinning top or half-way down the sharpened pencil. Spin the circle as quickly as you can on the black paper. What colour is made?



5. Spin the other coloured circles. What colour is made by each circle?

Module Summary

You have explored light and shadows in this module. You have found out what makes light and what affects or changes light. You discovered how light sources have changed over time and looked at some present and future uses of light.

Did you enjoy experimenting with white light and coloured light? Did you enjoy making a periscope and kaleidoscope?

When you look at the world now, remember that you can see it because of the way that light travels, bounces, bends, and splits apart.

Now turn to the checklist in Assignment Booklet 3B and make sure you have collected everything to send to your teacher. Also, be sure to fill out your Student Feedback Form.

Glossary

absorb: to take in and hold

astronomer: one who studies planets, stars, and other objects in space

astronomy: the study of planets, stars, and other objects in space

concave lens: a piece of glass or plastic that is thicker around the edges than in the middle

convex lens: a piece of glass or plastic that is thinner at its edges and thicker in the middle

electricity: a form of energy that can produce light, heat, and motion

filament: the wire (in a light bulb) that glows when electricity passes through it

fluorescent: a light source that is made of a long tube with a special gas inside that lights up when electricity flows from one end of the tube to the other

glance: hit and move off at a slant

incandescent: a light source (for example, a light bulb) that uses a vacuum and filament

light source: an object that makes its own light

luminous: having its own light

lunar: having to do with the Moon

opaque: not allowing light to travel through

primary colours of light: red, green, and blue

reflect: to turn back, bounce back, or throw back light, heat, or sound

refraction: the bending of light as it passes through a transparent object

shadow: a dark shape caused by something or someone blocking light

spectrum: the band of colours made by splitting up white light

translucent: allowing some light to pass through, but not enough for clear images

transparent: allowing most light to travel through

vacuum: a space containing no air, or from which the air has been removed

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